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BOEING

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USAAVLABS Technical Report
November, 1972

TEST RESULTS REPORT AND FINAL TECHNOLOGY DEVELOPMENT REPORT, HLH/ATC TRANSMISSION HOUSING MATERIAL EVALUATION

FINAL REPORT

By

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Prepared by

The Boeing Company
Vertol Division

for

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

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SUMMARY

The majority of the tensile, fatigue, and crack propagation test results were obtained from ZE41A magnesium sand castings which were subjected to a one-stage precipitation heat treatment cycle of 480°F for 24 hours. This treatment was developed by experiment at the vendor's facility and involved the testing of 108 separately cast tensile test coupons after exposure to four different thermal cycles including the two-stage treatment recommended by Magnesium Elektron of England who introduced and developed this alloy. Mechanical test results of thin and thick material from all castings of ZE41A-T5 given the one-stage treatment met or exceeded AMS 4439 requirements. Similar tests on ZE41A-T5 casting which was given a two-stage thermal treatment exhibited average yield strength values below AMS requirements.

Tensile tests of all the nonwelded ZE41A-T5 specimens, even those removed from 3-inch-thick sections, indicated strengths and elongations in excess of AMS 4439 requirements (Figure 2). All the welded specimens, with the exception of those removed from the thickest section, exhibited mechanical properties exceeding the requirements for nonwelded material. Maximum thickness of the HLH transmission housings is anticipated to be from 1.5 to 2.0 inches.

Bending fatigue tests of the "as-cast" surface of nonwelded ZE41A-T5 specimens indicated that those from the thin section of the casting had an average fatigue strength approximately 20 percent higher than those from the thick section of the casting (Figure 5). This difference in fatigue performance is attributed to the surface condition and microstructural factors. This fatigue testing conducted on the ZE41A-T5 material indicates that the current fatigue design allowable stress currently used for AZ91C-T6 transmission housings is applicable and is conservative for ZE41A-T5.

The thick sections revealed a problem of surface finish and microstructure associated with the geometry of the casting which is similar to an ingot of magnesium 16 inches x 14 inches x 30 inches. Chill bars used for cooling this mass of metal could only be located on the drag surface (bottom) since the cope half of the mold contained several risers. In actual production of transmission housings, this particular problem would not occur. Due to the geometry of thick sections, such as transmission mounting pad areas, it is possible to place chills on three or four sides of the pad. This permits optimum cooling rates and should limit the degree of segregation in the microstructure. The optimum test casting for this type of evaluation should have an irregular profile with 3-inch-wide bars having variable heights. This shape would permit the foundry to chill the casting in a manner

more representative of good casting technology.

Welding proved detrimental to the fatigue strength of ZE41A-T5 magnesium. Welded specimens from both thin and thick sections of the casting showed a 10 to 20 percent lower fatigue strength than nonwelded specimens from corresponding sections. It should be noted, however, that currently weld repair is permitted only in the low stress, noncritical areas of a helicopter transmission housing. Under this condition, weld repair offers an effective economic means of salvaging many castings without compromising structural integrity. The testing described herein indicates that this approach could also be utilized with HLH transmission housings of ZE41A-T5.

Fatigue crack propagation testing of ZE41A-T5 material conducted in air at 10 Hz indicated essentially the same crack growth rate characteristics for welded and unwelded specimens utilizing material from thick or thin sections of the casting (Figure 20). Tests conducted to compare the fatigue crack growth characteristics of ZE41A-T5 and AZ91C-T6 indicated that the AZ91C-T6 material had a crack growth rate which, on the average, was two to three times slower than that of the ZE41A-T5 material. While this difference is primarily attributed to microstructural differences and is considered significant, there is a question as to how well the AZ91C-T6 material used in this program represented yield strength and elongation properties of actual transmission housing castings. The low yield strength and high elongation of the material are not considered representative of typical properties determined from tests on material removed from actual housings.

Since minimum wall thickness and stiffness requirements, rather than strength requirements, control the design of a typical helicopter transmission housing, small differences in strength properties from alloy to alloy are generally not significant. The previous successful structural performance of AZ91C-T6 housings is an indication that ZE41A-T5 housings having similar mechanical properties will also perform satisfactorily. In addition, ZE41A's superior castability, resulting in less scrappage, will provide a more cost-effective design.

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INTRODUCTION

Magnesium castings have been extensively used in the helicopter industry as a housing material for transmissions. The ZE41A-T5 magnesium sand casting alloy is reported by aircraft users in both the United Kingdom and Europe to be cost-effective due to virtual elimination of the microporosity problem which severely affected component deliveries of AZ91C-T6 alloy castings. Magnesium alloys containing rare earths, such as cerium in ZE41A-T5, are rated above the aluminum zinc alloys for general castability. Due to improved castability and minimal microporosity, mechanical properties should have improved uniformity. Since rejections of ZE41A-T5 castings will be lower, overall costs should compare with AZ91C-T6. In addition, the process of impregnation, which is applied to all AZ91C-T6 castings, will not be required for ZE41A-T5 due to the lack of microporosity in this alloy.

With the proposed usage of ZE41A magnesium for the HLH transmission housings, it became necessary to generate reliable static and fatigue strength properties using test coupons prior to fabrication and testing of full-scale transmission components. The proposed housings, fabricated from large size magnesium castings, have various thicknesses. To evaluate thickness effect on material properties such as fatigue strength, specimens were fabricated from both thick (3.0 inches) and thin (0.3 inch) areas of the test castings.

Weldments are not expected or designed into the transmission housings; however, repairs due to sand holes, chisel gouges, gas pockets and other foundry-produced defects invariably occur in production castings. Therefore, to evaluate the effect of welds on fatigue strength, tensile strength, and fatigue crack propagation rates, welds were made in the test castings to simulate such repairs. Figure 1 shows each type of specimen configuration after welding.

Fatigue crack propagation tests of welded and nonwelded magnesium specimens, fabricated from both AZ91C and ZE41A, were conducted to compare the crack propagation rates and to generate data for both materials. This data can be applied to various geometric models or components to determine fatigue crack growth response.

The tests were carried out over the time period from December 1971 to June 1972.

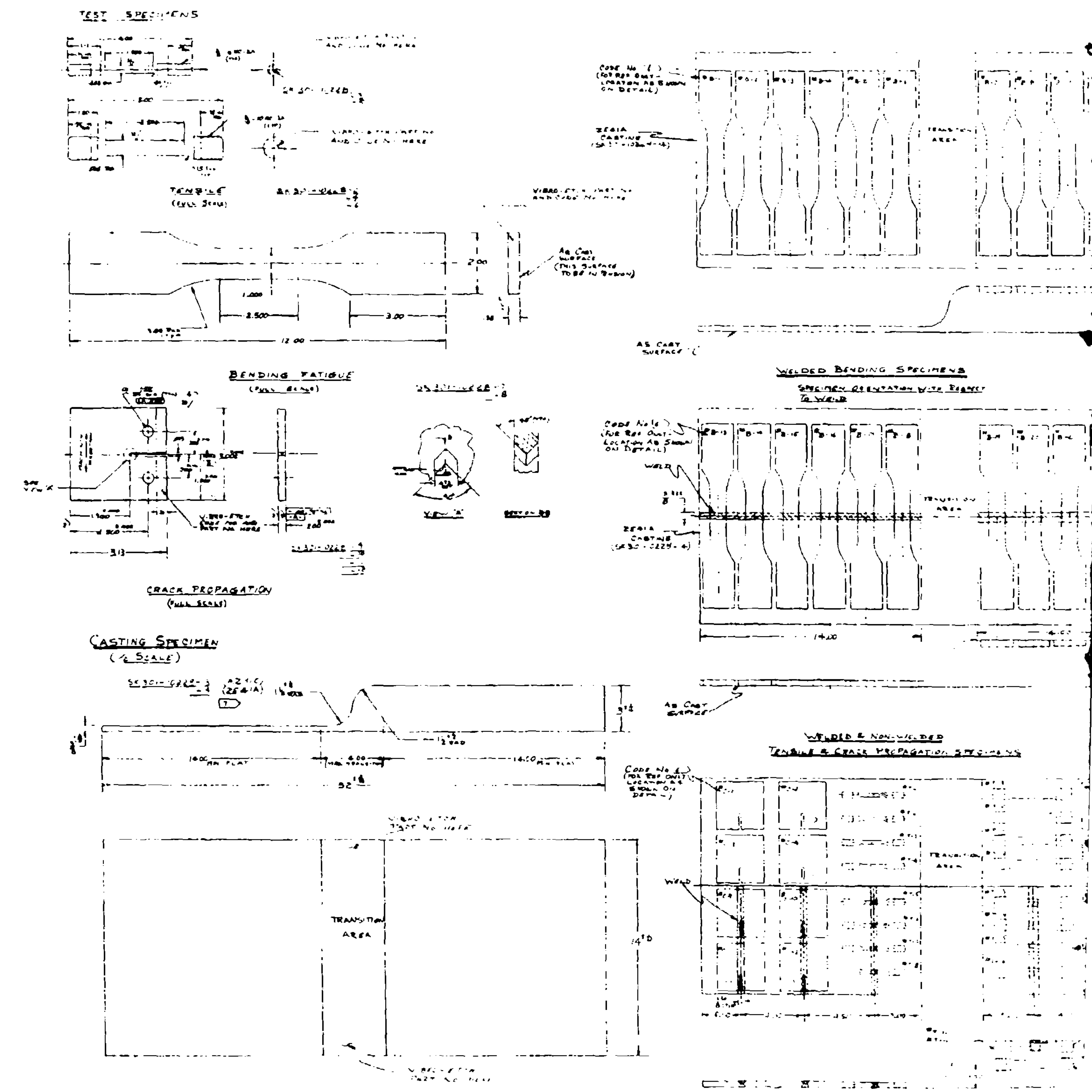
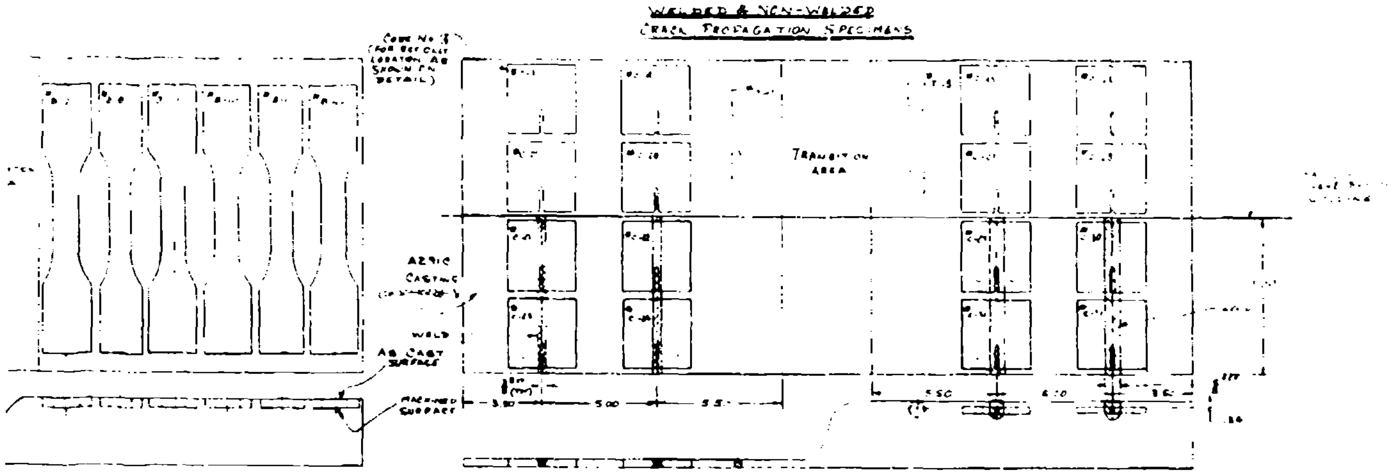
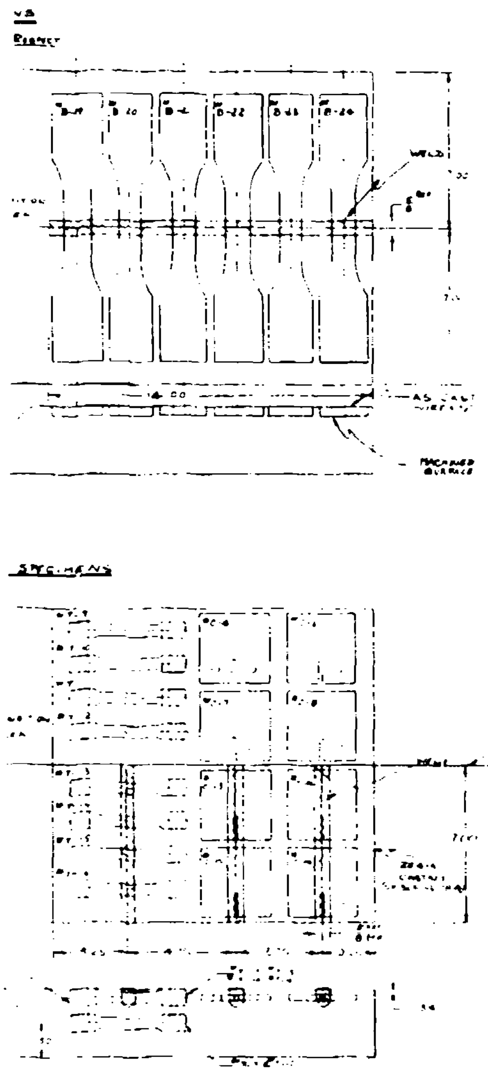
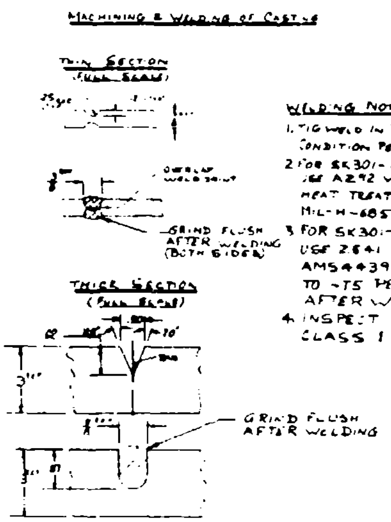


Figure 1. SK301-10228, Housing Materi







WELDING NOTES

1. TIG WELD IN THE AS CAST CONDITION PER MIL-W-18326
2. FOR SK301-10228-13 CASTING USE AZ92 WELD ROD AND HEAT TREAT TO -T6 PER MIL-H-6857 AFTER WELD
3. FOR SK301-10228-14 CASTING USE ZE41 WELD ROD PER AMS4439 AND HEAT TREAT TO -T5 PER MIL-H-6857 AFTER WELD
4. INSPECT PER D8-1054, CLASS 1A, GRADE A.

GENERAL NOTES:

1. BREAK ALL SHARP CORNERS .01 TO .03
2. 125 MACHINED SURFACE FINISH EXCEPT AS NOTED SEE BAC5307 FOR SURFACE ROUGHNESS
3. LOCATE CRACK STARTER NOTCH PERPENDICULAR TO MACHINING DIRECTION AS SHOWN IN F/D
4. BREAK SHARP CORNERS ON THESE HOLES .005 TO .010
5. INSPECTION REQUIREMENTS FLOURESCENT PENETRANT INSPECT PER BOEING DOC D8-1067
6. RECORD CODE NO AND VIBRO-ETCH IT ON THE FINISHED PART WITHIN THE AREA INDICATED AS SOON AS FEASIBLE IDENTIFICATION MARKINGS TO BE VERIFIED BY QUALITY CONTROL
7. INSPECT CASTING PER D8-1054, CLASS 1A, GRADE A

Qty	Part No.	Name	Material and Specification		
3	SK301-10228-14	CASTING SPEC	ZE41A [illegible] AMS4439 (7)	[illegible]	[illegible]
1	SK301-10228-13	CASTING SPEC	AZ92 CASTING [illegible] (7)	[illegible]	[illegible]
8	SK301-10228-12	CRACK PROP SPEC (WELDED)	[illegible] CASTING	[illegible]	[illegible]
6	SK301-10228-11	CRACK PROP SPEC (WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	[illegible]
6	SK301-10228-10	CRACK PROP SPEC (NON-WELDED)	M/F SK301-10228-13 CASTING	PV-F-105	VE
8	SK301-10228-9	CRACK PROP SPEC (NON-WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	VE
12	SK301-10228-8	BENDING FATIGUE SPEC (WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	VE
12	SK301-10228-7	BENDING FATIGUE SPEC (NON-WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	VE
4	SK301-10228-6	UNIAXIAL TENSILE SPEC (WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	VE
4	SK301-10228-5	UNIAXIAL TENSILE SPEC (WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	VE
1	SK301-10228-4	UNIAXIAL TENSILE SPEC (NON-WELDED)	M/F SK301-10228-13 CASTING	PV-F-105	VE
	SK301-10228-3	UNIAXIAL TENSILE SPEC (NON-WELDED)	M/F SK301-10228-13 CASTING	PV-F-105	[illegible]
4	SK301-10228-2	UNIAXIAL TENSILE SPEC (NON-WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	[illegible]
4	SK301-10228-1	UNIAXIAL TENSILE SPEC (NON-WELDED)	M/F SK301-10228-14 CASTING	PV-F-105	[illegible]

LIST OF MATERIAL

THE BOEING COMPANY
VERTOL DIVISION PHILADELPHIA PA

HOUSING MATERIAL EVALUATION

77272 SK301-10228

HLH-ATC

sing Material Evaluation

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TEST PROGRAM

PROGRAM PLAN

All test coupons were designed to be removed from four-step (slab) castings per SK301-10228 (Figure 1). Three -14 parts furnished all the fatigue, tension, and crack propagation specimens of the magnesium alloy ZE41A-T5. A fourth casting designated -13 was cast of AZ91C-T6 magnesium for crack propagation and tension specimens. The weldments for the ZE41A tensile, fatigue, and crack propagation specimens were simulated repair TIG (tungsten, arc, inert gas) welds made per MIL-W-18326 using rods of ZE41 per AMS 4439. Welds were ground flush with the casting surface, x-ray inspected, and heat treated to the T5 condition to simulate weld repairs of a transmission or production housing. Welds in the AZ91C specimens were made using an AZ92 welding rod. After welding, the specimens were heat treated to the T6 condition per MIL-H-6857. Test specimen configuration, weld geometry and related specifications and special nondestructive test requirements were identified on the drawing. Position of the specimens relative to the mass of the casting was established together with the specimen identity.

Testing per drawing included a total of 74 specimens divided as follows:

ALLOY	SPECIFICATION	TENSION	FATIGUE	CRACK PROPAGATION
ZE41	AMS 4439	16	24	16
AZ91	QQ-M-56	2	--	16

In all cases except for AZ91C-T6 tensile coupons, specimens were equally divided between thick and thin areas as well as welded and nonwelded configurations per the drawing.

MATERIAL

Five castings were utilized in the coupon test program. Three ZE41 castings and one AZ91 casting were furnished by Vendor A. A fifth ZE41 test casting was furnished in the welded and nonwelded condition by Vendor B. A summary of chemical analysis and heat treat batch numbers of the four Vendor A castings are included in Table I. The AZ91 casting was heat treated per MIL-H-6857. Since this specification does not presently cover ZE41 material, tensile tests on 108 separately cast bars were conducted at Vendor A facility prior to heat treating the test castings. Based on these results, the most consistent average and individual mechanical properties were obtained by using a thermal cycle of 480° F for 24 hours. Vendor A ZE41 castings all received this treatment. The ZE41A-T5 casting furnished by Vendor B was heat treated for 2 hours at 625°F followed by aging for 16 hours at 345°F.

TABLE I. CHEMICAL ANALYSES FROM VENDOR CERTIFICATION							
			Composition - Percent				
Alloy	Melt Number	Heat Treat Batch Number	Aluminum	Zinc	Total Rare Earth Cerium	Zirconium	Magnesium
ZE41A	J2011M	M008	---	4.3	1.4	.75	Balance
ZE41A	J2211M	M008	---	4.2	1.1	.71	Balance
ZE41A	L3011M	1122-5	---	4.3	1.2	.74	Balance
AZ91C	L2917R	1102-6	8.6	.80	---	---	Balance
AMS 4439 Requirement (ZE41A)				3.5/5.0	.75/1.75	.4/1.0	Balance
QQ-M-56 Requirement (AZ91C)			8.1/9.3	.4/1.0	---	---	Balance

All applicable specifications and technical requirements for the test castings are conveyed by general notes on the engineering drawing (Figure 1). Flag note number 7 specified that inspection should be accomplished per D8-1059. This included acid etching of all cast surfaces prior to penetrant inspection. Inadvertently, this step which aids identification of defects was not done. Penetrant and radiographic inspections were subsequently completed and all test castings were certified to be acceptable. Radiographs of the 3.0-inch-thick area did not show the surface pits, oxides or segregation characteristics due to the low sensitivity of 2 percent or 0.060 inch penetration in the 3-inch section. These discrepancies were not observed until the failed fatigue specimens were examined fractographically and by x-ray. Present acceptance practice of inspection with the AZ91C-T6 alloy is based entirely on the radiographic quality. When a surface discrepancy is evident by fluorescent penetrant inspection, radiographs are used to judge whether to accept or reject the casting.

TENSILE TEST

Test Specimen Configuration and Preparation

Specimens were tested in the following conditions:

1. Unwelded from thick, 3.0 inches, and thin, 0.3 inch, sections of a ZE41A casting.

2. Welded from thick, 3.0 inches, and thin, 0.3 inch, sections of a ZE41A casting.

Sixteen specimens, four for each condition and thickness, were tested.

Thin specimens were machined to the R3 configuration and thick specimens to the R1 configuration of Federal Test Method Standard Number 151, Method Number 211. End portions of the 3 inch and 5-1/2 inch lengths were threaded for 5/8 inch and 1 inch lengths with 3/8-16 NC and 3/4-10 NC threads, respectively (SK301-10228-1 through -6).

Test Procedure and Test Setup

Tests were performed on a Baldwin Lima Hamilton machine with a 60,000-pound capacity. Grip end attachments were threaded, and axial alignment was achieved by a self-aligning feature in the top and bottom heads. The indicated loads were maintained within 1 percent of the true applied loads. A strain rate of 0.0005 inch/inch/minute was utilized.

Test Results

Tensile test results on 22 specimens of ZE41A-T5 and AZ91C-T6 material are shown in Table II. Average tensile properties for ZE41A-T5 magnesium are shown graphically in Figure 2. All eight coupons from the 0.3-inch-thick area of the casting met minimum and average requirements specified in AMS 4439. Four of these were notched and welded to simulate casting repair procedures. Four of the thick coupons representing the basic magnesium casting at locations both near the surface and at midthickness (No. TK9 and TK10) also met average and individual AMS requirements. Thick welded coupons met yield strength requirements applied to unwelded coupons. However, all tensile strengths and three elongation values for these specimens were below unwelded specification limits. The average tensile strength for welded specimens was 15 percent below specification limits, and elongation values for welded specimens were 30 percent below the requirement of 2.5 percent for unwelded material. It is apparent, based on this test data from one casting, that the magnesium alloy of zinc and rare earth elements has uniform mechanical properties

TABLE II. TENSILE TEST RESULTS FOR ZE41A-T5 AND AZ91C-T6 MAGNESIUM

Material	Section of Casting (3)	Specimen Description	No.	Diameter (in.)	Area (in^2)	Load (lb)	UTS (ksi)	Load (lb)	YTS (ksi)	% Elong. in/in
ZE41A-T5 (1)	Thin	Non-w[illegible]ded	1	.252	.050	1756	35.1	1075	21.5	4.0
			2	.252	.050	1530	30.6	1060	21.2	4.5
			3	.252	.050	1502	30.0	1040	20.8	5.0
			4	.252	.050	1446	28.9	1030	20.6	3.5
		Welded	5	.251	.0495	1384	28.0	1030	20.8	3.0
			6	.251	.0495	1332	26.9	1060	21.4	2.0
			7	.252	.050	1590	31.8	1120	22.4	5.0
			8	.252	.050	1646	32.9	1080	21.6	2.5
	Thick	Non-welded	9	.505	.2003	5600	28.0	4080	20.4	2.5
			10	.505	.2003	6174	30.6	3900	19.5	5.5
			11	.506	.201	5940	29.6	3950	19.7	4.5
			12	.506	.201	5800	28.9	3850	19.2	4.5
		Welded	13	.506	.201	5090	25.3	3900	19.4	1.0
			14	.506	.201	4760	23.7	4100	20.4	1.0
			15	.505	.2003	5162	25.8	4160	20.7	2.0
			16	.506	.201	3767	18.7	3767	18.7	1.0
ZE41A-T5 (2)	Thin	Non-welded	17	.251	.0495	1668	33.7	1090	22.0	*
			18	.251	.0495	1648	33.3	1050	21.2	*
	Thick		19	.506	.201	5970	29.7	3618	18.0	*
			20	.505	.2003	5970	29.8	3605	18.0	*
AZ9[illegible]-T6	Thin	Non-welded	21	.252	.050	2025	40.5	740	14.8	12.0
	Thick		22	.506	.201	7517	37.4	2650	13.2	13.0

*Gage out

ZE41A-T5	AMS 4439 Requirements	UTS	YTS	% Elong'n
	Average	28.0	19.5	2.5
	Individual	26.0	17.5	2.0

AZ91C-T6	QQ-M-56 Min. Requirements	UTS	YTS	% Elong'n
	Average	25.5	14.5	0.75
	Individual	17.0	12.0	—

(1) All material heat treated 480°F for 24 hours

(2) Supplied by Vendor B - Casting was heat treated in two stages; 625°F--2 hours followed by 16 hours at 345°F

(3) Reference Drawing SK301-10228, Figure 1

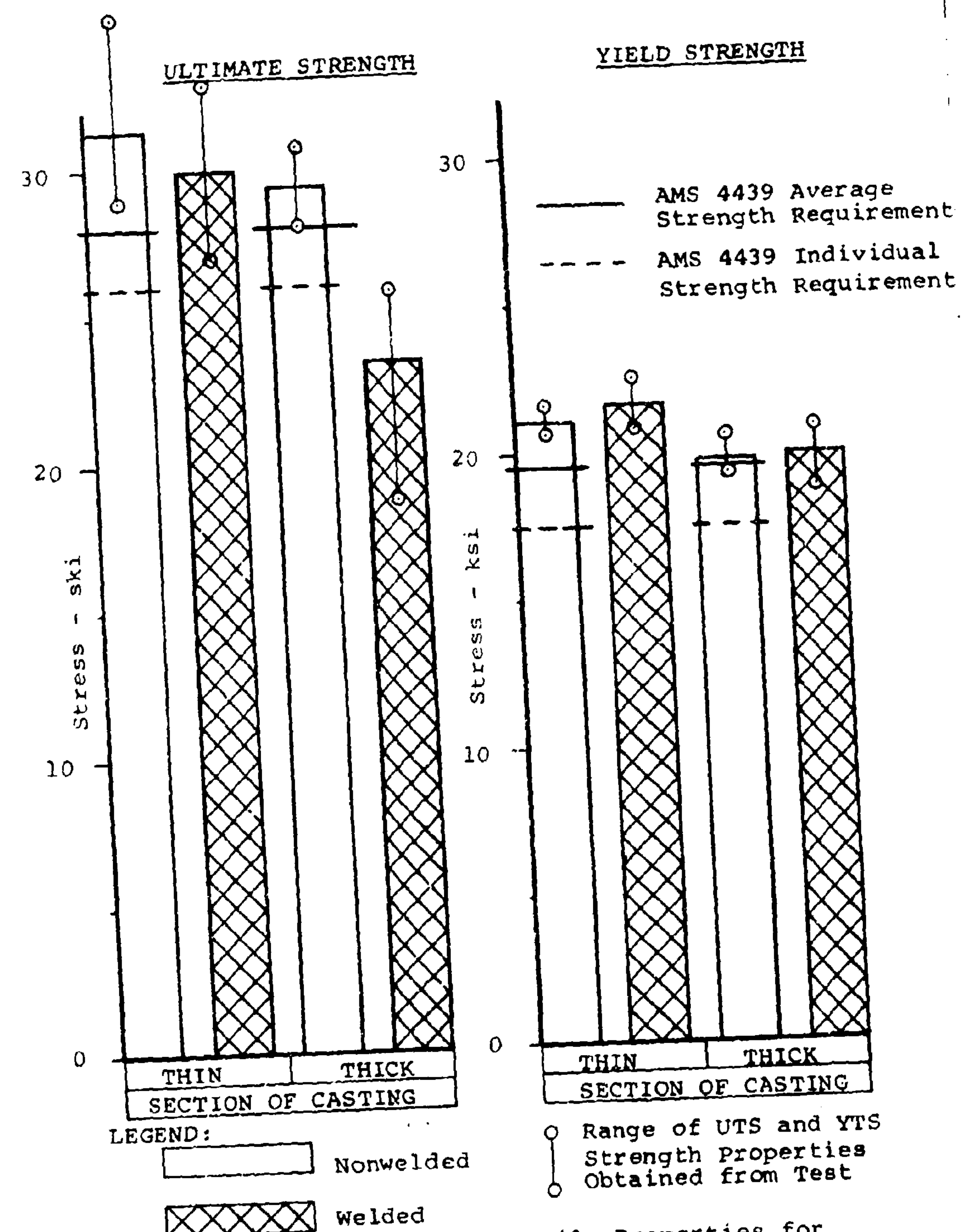


Figure 2. Average Tensile Properties for ZE41A-T5 Magnesium

which meet or exceed AMS requirements in both thick and thin areas. This indicates that there should be no restrictions on the part of foundries meeting properties in sections to 3-inches. Most sources, however, will take exception to AMS strength requirements in sections greater than 1½-inches. Guarantee will be made to meet 80 percent of the published values.

Tensile tests in addition to the proposed work plan included two AZ91C-T6 specimens machined from a Vendor A casting and four ZE41A-T5 specimens machined from a Vendor B slab type casting. These results are also tabulated in Table II.

Both of the AZ91C-T6 test specimens met QQ-M-56 minimum requirements. Yield strength values for ZE41A-T5 specimens removed from thick areas meet AMS requirements for individual bars but do not meet average value requirements.

FATIGUE TEST

The purposes of the fatigue testing of the ZE41A magnesium were threefold:

1. Determine if a difference in mechanical properties and/or fatigue strength exists between thin and thick sections of magnesium castings.
2. Determine if weld repair of magnesium is detrimental to fatigue strength.
3. Compare the fatigue strength of ZE41A magnesium with the fatigue strength of AZ91C.

Test Specimen Configuration and Preparation

Twenty-four ZE41A bending specimens were fabricated from large size castings as shown in Figure 1. These specimens, incorporating a "dog-bone" shape, were fabricated as one unwelded specimen cut from both thin and thick sections of the casting and two welded specimens cut from both thin and thick sections of the casting. Four groups, each consisting of six specimens and each representing one of the above conditions, were tested.

After machining the specimens to the dimensions specified by drawing SK301-10028-7 and -8, the edges were broken to approximately 0.010-0.030 inch radius. For all specimens except where noted, the surface and weld areas of the test specimens were tested with the "as-cast" and "as-cast plus welded" surfaces undisturbed. The weld beads and adjacent material on specimens B-14, B-16, B-17, and B-18 were surface dressed.

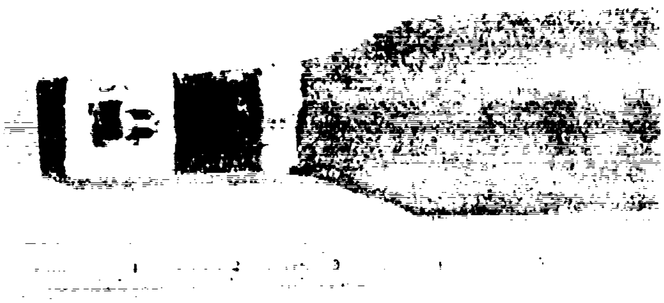
All nonwelded fatigue test specimens were of the configuration shown in Figure 1. This specimen configuration was to be used for all fatigue specimens, i.e., welded and nonwelded. Testing of three welded specimens (B-22, B-23, B-24) of this configuration resulted in two failures which did not pass through the weld. Examination of specimens B-22 and B-23 indicated considerable variation in the specimen thickness over the length of the test section. This thickness variation was due to irregularities associated with the "as-cast" surface (the other surface was machined). These particular welded specimens had the thickest portion of the test section at the weld area Since the test setup is designed to produce the same bending moment over the entire length of the test section, the thicker sections (the width is constant) have a greater section modulus and, therefore, experience a reduced bending stress. This situation was not conducive to meeting one objective of the test which was to evaluate the relative fatigue strength of the welded and unwelded material.

In order to expose both the parent and weld material to the same stress and thereby determine their relative performance, the specimen configuration was modified. In order to achieve the same stress along the length of the test section, the sides of specimens B-13, B-14, B-16, B-17, and B-18 were machined to provide a relatively constant section modulus. Specimen B-13 was inadvertently machined to the configuration shown in Figure 3. This configuration was not considered satisfactory because of the secondary radius; therefore, it was rejected because of the introduction of an increased stress concentration factor. This configuration was then reworked into a specimen with a gradual or constant radius as displayed in Figure 3. These specimens with this gradual radius (B-14, B-16, B-17) had all surfaces mistakenly machined.

Test Procedure and Test Setup

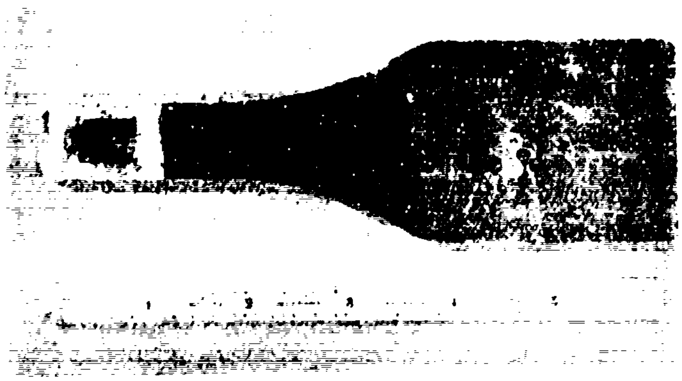
The fatigue tests of the 24 ZE41A specimens were performed on a Sonntag SF-1 U Fatigue Machine with a standard bending fixture utilizing four-point loading as displayed by Figure 4. All tests were performed at 30 cycles per second loading rate, and at a stress ratio (ratio of minimum load/maximum load) equal to zero. Tests were conducted in air at room temperature.

All specimens were strain gaged at their centerlines and mounted in a static four-point bending fixture for calibration. Known loads, as measured by a load cell, were applied at the constant bending section of the specimen to establish a bending strain output versus load input. Although the calibration data was not used in determining the applied stresses, it did serve a purpose. By using the calibration data, stresses calculated by multiplying modulus of elasticity times strain output ($E\epsilon$) can be checked for accuracy and



SPECIMEN B-1
(Parallel Sides)

SPECIMEN B-13
(Radius at Test Section)



SPECIMEN B-14
(Sides Contoured for Constant Section Modulus)

NOTE: Photographs show view of bottom surface of specimens after fatigue testing.

Figure 3. Fatigue Test Specimen Configurations

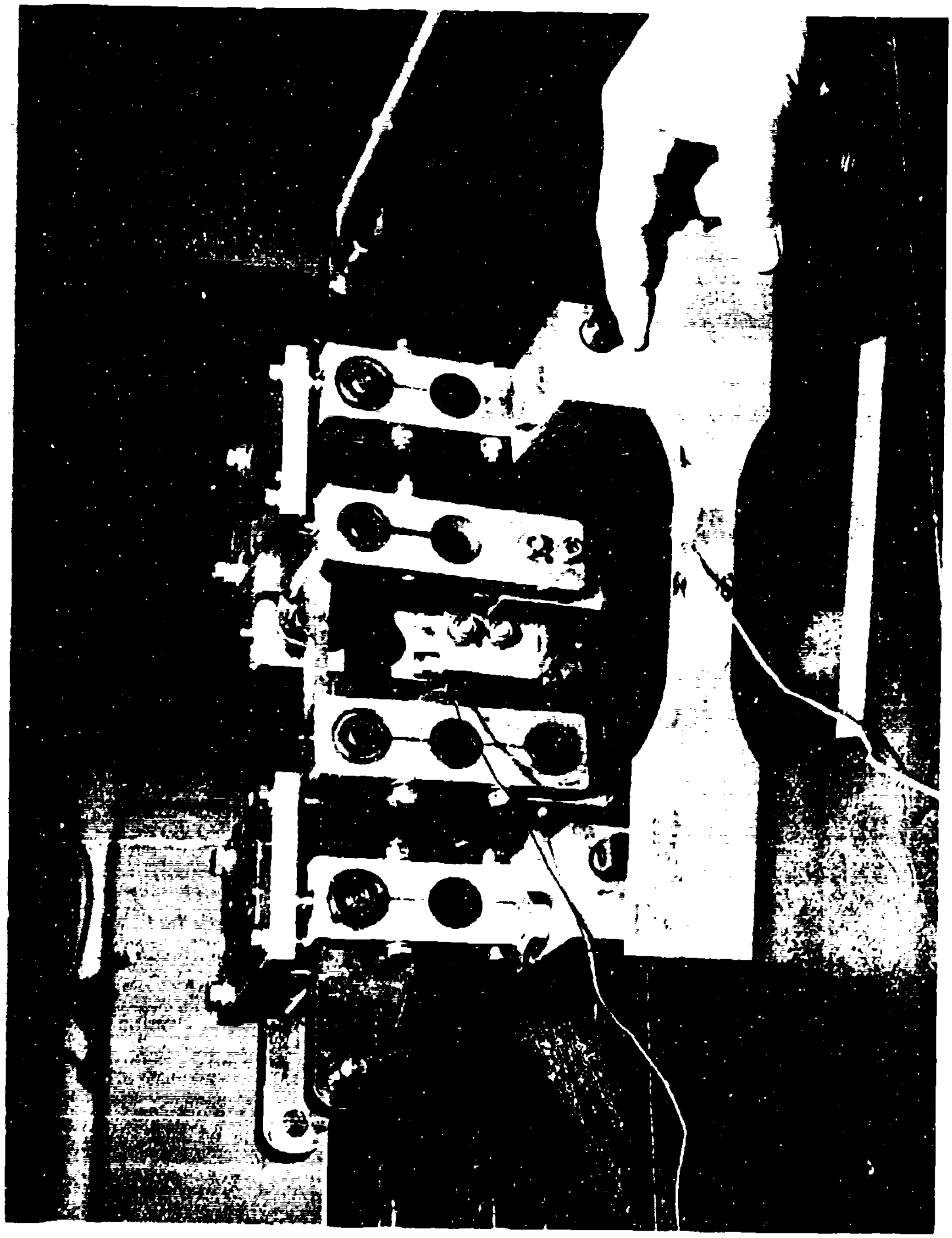


Figure 4. Fatigue Test Bending Fixture

errors by using the equation $\sigma = Mc/I$.

The strain gage for each specimen was bonded to the compression loaded surface. The "as-cast" surface, for all specimens except B-14, B-16, and B-17 which had all surfaces machined, was subjected to tensile stresses created by the applied bending moment. The specimens were stressed to a predetermined level by applying loads and monitoring the strain output. Knowing the modulus of elasticity to be 6.5×10^6 psi for ZE41A, the stress was calculated as $E \times \epsilon$. This is the stress shown on the S-N (stress-number of cycles) curves (Figures 6 through 9).

Test Results

The results of the fatigue tests are summarized graphically in Figure 5. The detailed test data are presented in Tables III and IV, and displayed by the S-N curves on Figures 6 through 9.

Comparison of nonweld fatigue data obtained from specimens fabricated from the thin section of the casting (Figure 6) with data obtained from specimens fabricated from the thick section of the casting (Figure 7) shows a significant difference in fatigue strength. The estimated average fatigue strength is ± 7000 psi at 5×10^7 cycles (at a stress ratio of zero) for specimens from the thin section, and ± 5900 psi for specimens from the thick section. The data shown in Figures 6 and 7 were obtained from unwelded specimens and from welded specimens which did not fail in the weld or heat-affected zone. A probable explanation for the difference in fatigue performance is the relatively poorer surface quality of the thick section of casting. The porosity and segregation associated with the thick section proved to be the origin of failure in many specimens and is believed to have caused the fatigue strength to be lower than that of the thin section with a surface relatively free of porosity.

Side-by-side photographs illustrating the microscopic fracture characteristics plus the origin location and microstructural details of the origin sites are displayed in Figures 10 through 13. Dimensional aspects of fatigue origins on all specimens relative to the spanwise length and section thickness are tabulated in Table V. For specimens representing the thin section of casting, subsurface origins were apparent on specimens B-1, B-2, B-4, and B-5. Of these, B-1, B-4, and B-5 were directly related to gross oxide skins of zirconium or a combination of zirconium and cerium. The microstructure of specimen B-2 was unique since the origin area displayed both entrapped oxides and enlarged grains.

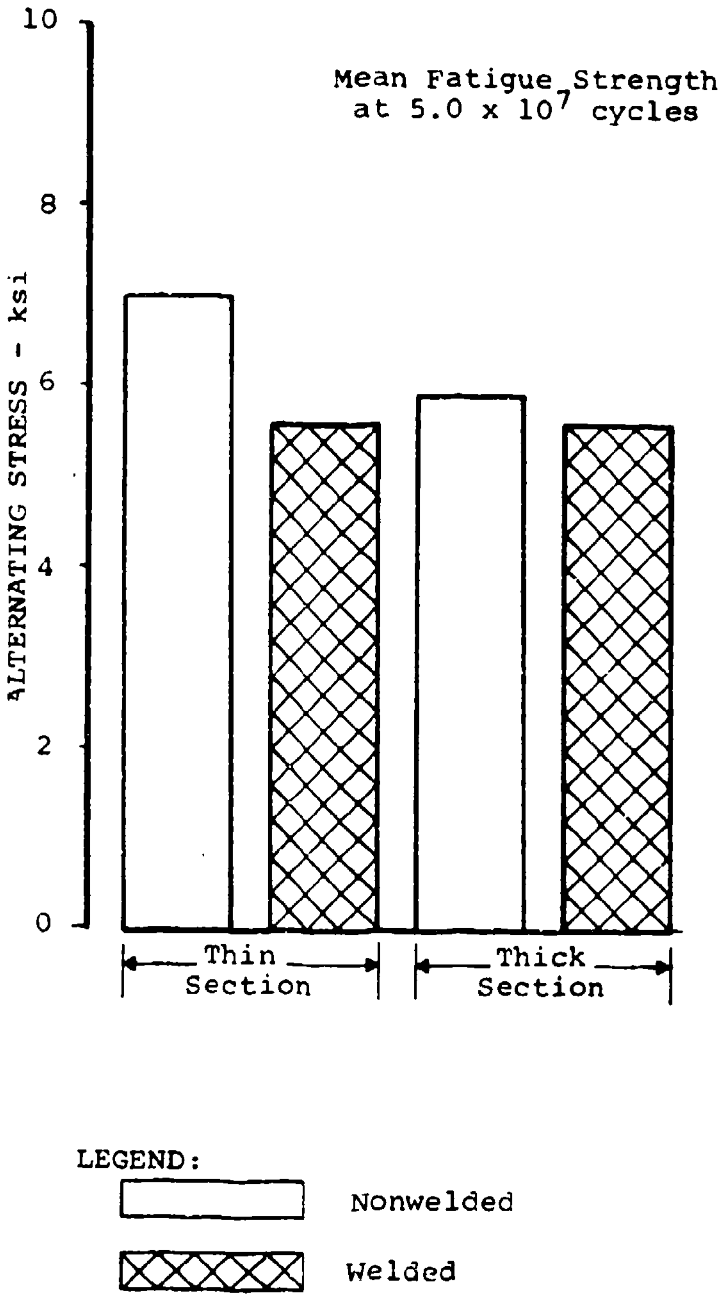


Figure 5. Mean Fatigue Strength for ZE41A-T5 at a Stress Ratio of Zero.

TABLE III. HLH FATIGUE TEST DATA FOR ZE41A MAGNESIUM

Casting Section: Thin   Stress Ratio: R=0   Test Frequency: 30 cps

Specimen Description	Number	Strain Gage Reading Micro-Inch/Inch		Applied Bending Stress (psi) $\sigma = E\,\epsilon$		Number of Cycles to Failure X10^6	Remarks
		Steady	Alter-nating	Steady	Alter-nating		
Nonwelded	B-1	1277	1277	8300	8300	0.361	Failure at Radius
	B-2	1308	1308	8500	8500	0.268	Failure in Test Section
	B-3	1155	1155	7500	7500	10.316	Runout
	B-3	1462	1462	9500	9500	0.222	Failure in Test Section
	B-4	770	770	5000	5000	10.640	Runout
	B-4	1262	1262	8200	8200	31.137	Runout
	B-4	1385	1385	9000	9000	20.774	Failure in Test Section
	B-5	1230	1230	8000	8000	32.857	Runout
	B-5	1262	1262	8200	8200	18.866	Runout
	B-5	1353	1353	8800	8800	10.000	Runout
	B-5	1492	1492	9700	9700	0.439	Failure in Test Section
	B-6	1385	1385	9000	9000	0.107	Failure at Radius
	B-13*	1303	1308	8500	8500	0.303	Failure at Radius
	B-14*	1000	1000	6500	6500	2.561	Failure in Test Section
	B-15*	770	770	5000	5000	15.671	Runout
	B-15*	1077	1077	7000	7000	0.578	Failure at Radius
	B-17*	846	846	5500	5500	15.501	Runout
Welded	B-13	1308	1308	8500	8500	0.303	Failure at Small Radius
	B-14	1000	1000	6500	6500	2.561	Failure Outside Weld
	B-15	770	770	5000	5000	15.671	Runout
	B-15	1077	1077	7000	7000	0.578	Failure at Radius
	B-16	923	923	6000	6000	0.338	Failure at Weld
	B-17	846	846	5500	5500	15.501	Runout
	B-17	923	923	6000	6000	0.754	Failure at Weld
	B-18	1155	1155	7500	7500	0.264	Failure at Weld

(For notes see Table IV)

TABLE IV. HLH FATIGUE TEST DATA FOR ZE41A MAGNESIUM

Casting Section: Thick   Stress Ratio: R=O   Test Frequency: 30cps

Specimen Descrip.	Number	Strain Gage Reading Micro-Inch/Inch		Applied Bending Stress (psi) $\sigma = E\epsilon$		Number of Cycles to Failure $X10^6$	Remarks
		Steady	Alter-nating	Steady	Alter-nating		
Non-welded	B-7	1385	1385	9000	9000	0.241	Failure in Test Section
	B-8	1308	1308	8500	8500	0.367	Failure in Test Section
	B-9	1230	1230	8000	8000	0.495	Failure in Test Section
	B-10	1155	1155	7500	7500	0.582	Failure at Radius
	B-11	923	923	6000	6000	0.930	Failure in Test Section
	B-12	770	770	5000	5000	0.869	Failure in Test Section
	B-21*	923	923	6000	6000	10.027	Runout
	B-21*	1077	1077	7000	7000	13.715	Runout
	B-21*	1230	1230	8000	8000	0.480	Failure at Radius
	B-22*	770	770	5000	5000	10.041	Runout
	B-22*	1077	1077	7000	7000	0.777	Failure in Test Section
	B-23*	1308	1308	8500	8500	0.327	Failure at Radius
Welded	B-19	923	923	6000	6000	0.300	Failure at Weld
	B-20	1000	1000	6500	6500	0.188	Failure at Weld
	B-21	923	923	6000	6000	10.027	Runout
	B-21	1077	1077	7000	7000	13.715	Runout
	B-21	1230	1230	8000	8000	0.480	Failure at Radius
	B-22	770	770	5000	5000	10.041	Runout
	B-22	1077	1077	7000	7000	0.777	Failure Outside Weld
	B-23	1308	1308	8500	8500	0.327	Failure at Radius
	B-24	1155	1155	7500	7500	0.270	Failure at Weld

NOTES: *Testing of welded specimen; failure occurred outside weld
◁ All surfaces of specimen were machined

Grain enlargement has usually been associated with zirconium depleted areas by researchers in the magnesium casting industry who have studied alloys containing rare earths such as zirconium and thorium.[1]

Cracking in specimens B-3 and B-6 initiated from surface oriented cavities which displayed no inherent material discrepancies. It is postulated that these impressions/cavities may be associated with the foundry practice of cleaning and coating the molds prior to assembly and pouring operations or from oxidation pits due to incorrect furnace atmosphere.[2]

Although the predominant mode of failure for thin section specimens was transgranular, fractures in this group were characterized by a mixed mode and contained both intergranular and transgranular cracks.

Of the specimens representing the thick section of casting, four specimens (B-7, B-8, B-11, and B-12) had fractures which originated at surface oriented pits (Table V). Specimen B-7 displayed large oxide inclusions and grain growth in addition to the surface pit. The remaining specimens, B-9 and B-10 displayed subsurface origins which were located at oxide inclusions. Fracture topography on these six specimens was predominantly intergranular rather than transgranular as observed on the six thin coupons. The microstructure of specimens B-7 through B-12 disclosed the segragate compound Zn_2Zr_3. This compound usually occurs at high temperatures when the melt is saturated with zirconium. Excess zirconium precipitates and segregates by density difference at the bottom of the casting. This segregation constituent probably explains the intergranular nature of the fracture surface on the specimens removed from the thick area.

The x-ray quality of these samples revealed numerous oxides and some segregation whereas radiographic inspection of samples from the thin area revealed no discrepancies. Temporary acceptance standards utilizing the thin area radiographs as acceptable and thick area radiographics as unacceptable have been established with the vendor. Preliminary ASTM E115 ratings of one and three have been designated for these two conditions relative to oxides and segregation. Definite radiographic standards for magnesium alloys bearing cerium and zirconium should be available from ASTM within 1 year.

Comparison of weld and nonweld fatigue data indicates that welding is detrimental to the fatigue strength of ZE41Z-T5 magnesium. For specimens fabricated from the thin section of the casting, the fatigue strength of the unwelded specimens (Figure 6) is greater than that of the welded specimens (Figure 8). Figures 7 and 9 show a similar trend for the specimens fabricated from the thick section of casting. 1

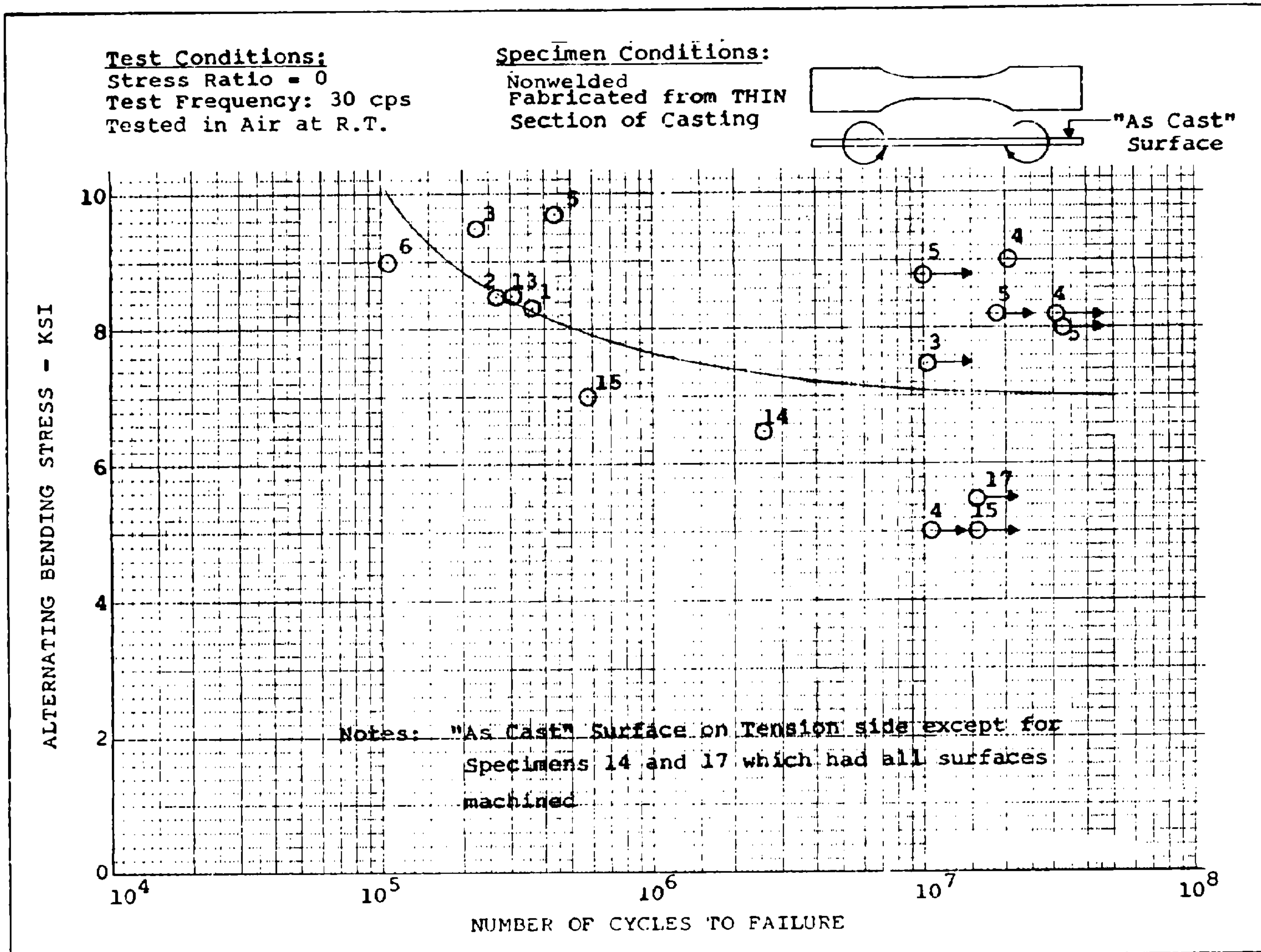


Figure 6. S-N Data for ZE41A Magnesium

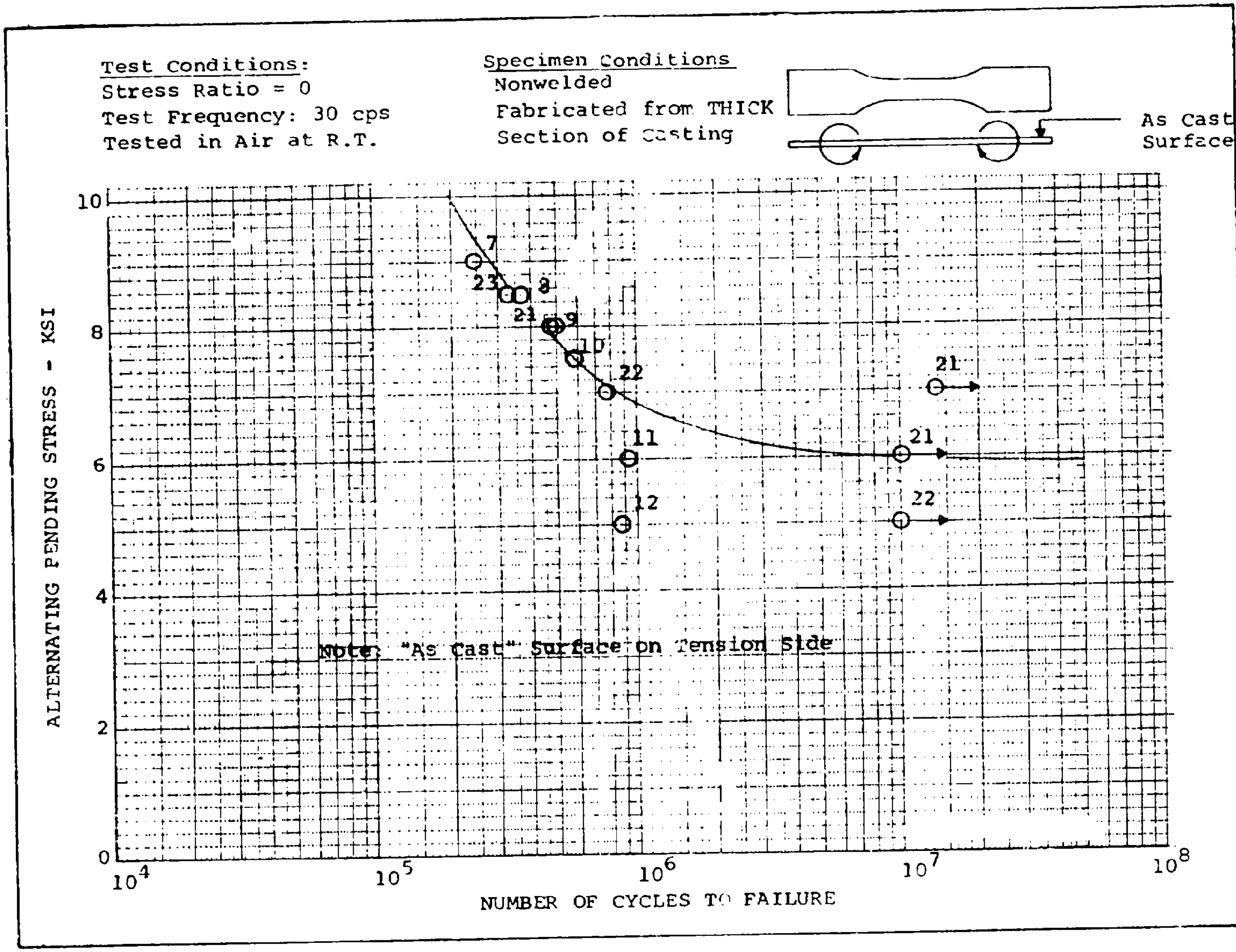


Figure 7. S-N Data for ZE41A Magnesium

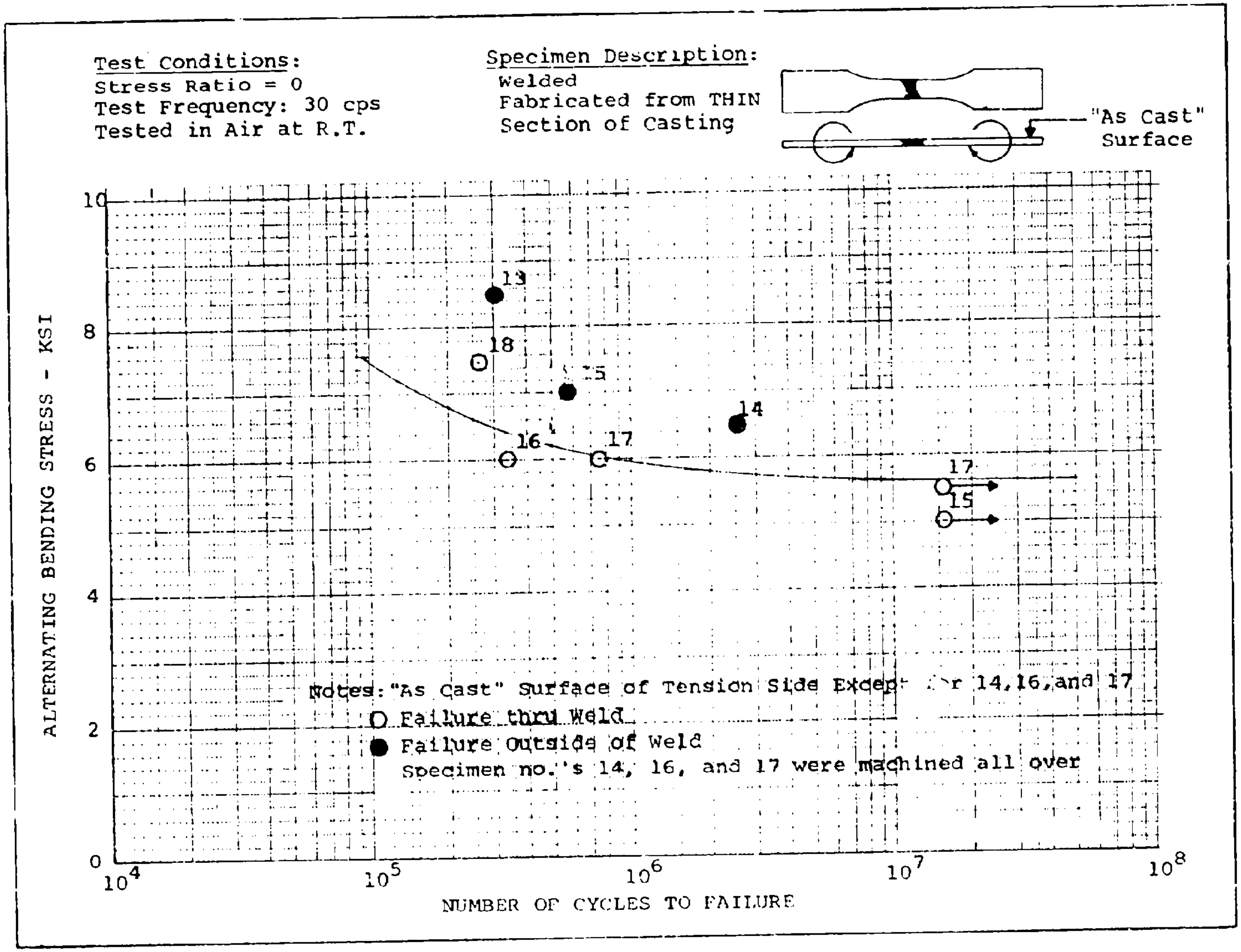


Figure 8. S-N Data for ZE41A Magnesium

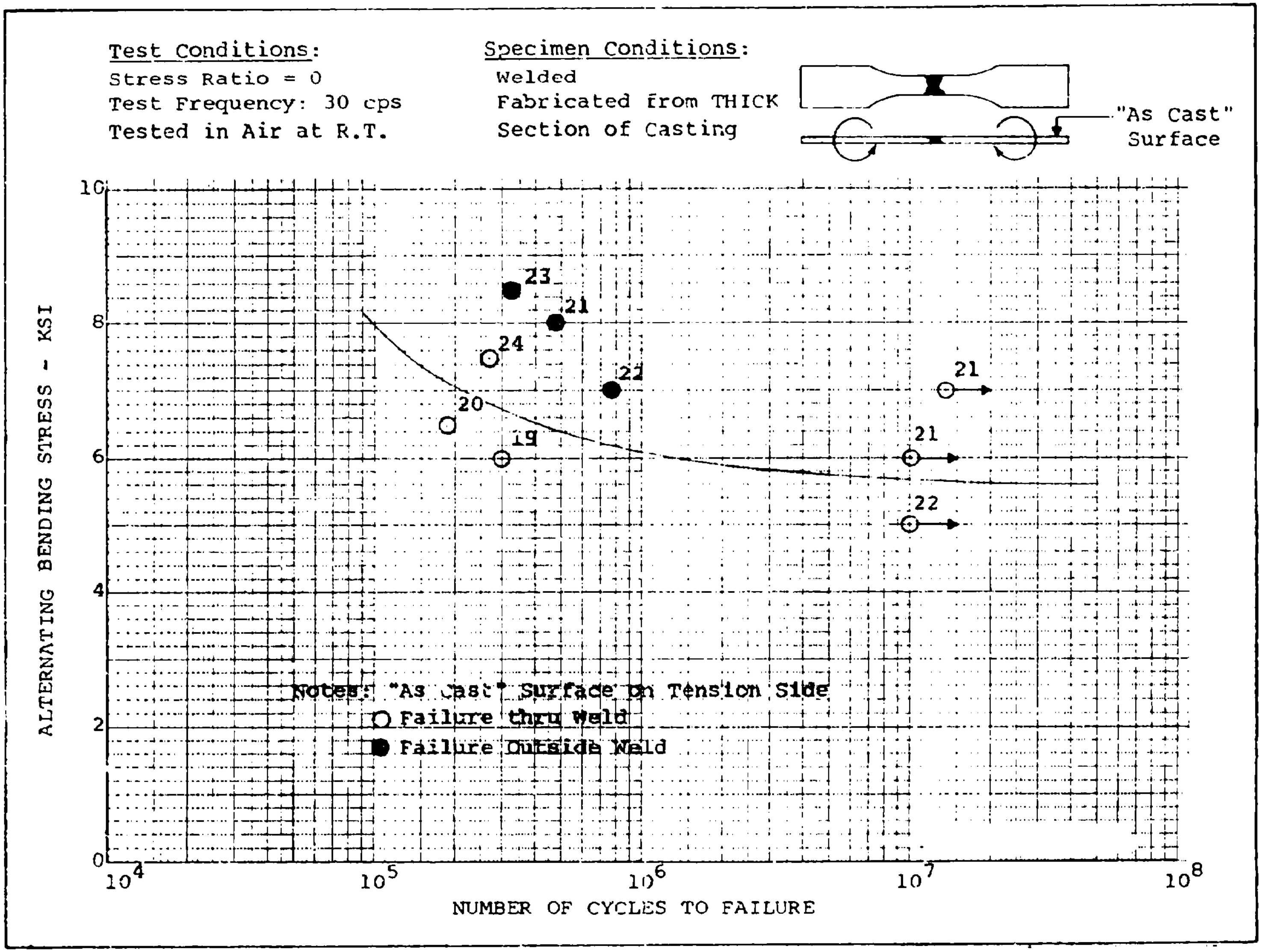


Figure 9. S-N Data for ZE41A Magnesium

TABLE V. RESULTS OF METALLURGICAL EXAMINA

SPEC-IMEN NO.	FRACTURE LOCATION	ORIGIN LOCATION
B-1	As-cast surface, 1.34" from center	Surface at edge of radius
B-2	As-cast, 1.20" from center	Side surface, .035" from as cast
B-3	As-cast, 0.98" from center	Surface cavity 0.20" from edge radius
B-4	As-cast, 1.26" from center	.010" Below surface, 0.150" from side ed
B-5	As-cast, 0.20" from center	.020" Below surface, 0.490" from side ed
B-6	As-cast, 1.48" from center	Surface cavity, .10" from edge radius
B-7	As-cast, 0.96" from center	Multiple origin from surface cavity & en
B-8	As-cast, 0.42" from center	Subsurface, .020" below surface; .030" f
B-9	As-cast, 1.05" from center	Multiple origin, subsurface; .005" below
B-10	As-cast, 1.72" from center	Subsurface, .010" below surface; .20" fr
B-11	As-cast, 0.75" from center	Surface cavity, .220" from side edge
B-12	As-cast, 1.30" from center	Surface cavity, .130" from side edge
B-13	As-cast, 0.35" from center	Surface, .010" from edge radius
B-14	Machined, 1.60" from center	Machined surface; .220" from side edge
B-15	As-cast, 1.45" from center	Surface, .050" from edge radius
B-16	Machined, 0.10" from center	Subsurface, .020" below surface
B-17	Machined	Surface, at edge radius
B-18	As-cast, 0.28" from center	Surface, edge of radius
B-19	Side surface, 0.50" from center	Subsurface, .050" below as-cast surface
B-20	As-cast, 0.40" from center	Surface, 0.40" from side edge
B-21	As-cast, 1.00" from center	Surface cavity, 0.88" from side edge
B-22	As-cast, 1.20" from center	Subsurface, .005" below surface, .38" fr
B-23	As-cast, 1.50" from center	Surface, edge of radius
B-24	As-cast, 0.26" from center	Subsurface weld crack, .050" below surfa

URGICAL EXAMINATIONS FOR BENDING FATIGUE SPECIMENS

LOCATION	DEFECT SIZE	REMARKS
	.020"Wide x .030"Deep	Entrapped particle at origin; Particle was .050"Long x .010" Thick
s cast	.020"Wide x .020"Deep	Shrinkage or entrapped part.
edge radius	.010"Wide x .030"Long	Surface cavity
" from side edge	.030"Wide x .010"Deep	Entrapped particle
" from side	.030"Wide x .020"Deep	Entrapped particle
edge radius	.050"Wide x .010"Deep	Surface cavity
ce cavity & entrapped oxide skin	Primary was .050"x.020"	Entrapped particle
rface; .030" from side edge	.040"Wide x .010"Deep	Entrapped particle
e; .005" below as-cast surface	Primary was .010"x.020"	Entrapped particle
urface; .20" from side edge	Primary was .020"x.020"	Entrapped particle
n side edge	.070"Wide x .018"Deep	Surface cavity
n side edge	.100"Wide x .030"Deep	Surface cavity
radius	.050"Wide x .015"Deep	Entrapped particle
rom side edge	.020"Wide x .012"Deep	Entrapped particle
radius	No visual defect	-----------------
urface	.10" Long	Weld defect; weld fracture
	No visual defect	Weld defect; weld fracture
	No visual defect	Weld fracture
s-cast surface	.0502"Long x .030"Wide	Weld fracture
edge	No visual defect	Weld fracture
n side edge	.010"Wide x .010"Deep	Surface cavity
urface, .38" from side edge	.020"Wide x .020"Deep	Entrapped particle
	.020"Wide x .030"Deep	Entrapped particle
50" below surface	.038" Long	Weld fracture

approximately 50 percent of the cases where failure occurred in the weld zone, the origin of failure was found to be at an area of porosity or other defects. Side-by-side photographs illustrating the microscopic fracture characteristics plus the origin location and microstructural details of the origin sites are displayed in Figures 14 through 17. Of the six specimens representing the thin section of casting, three specimens (B-13, B-14, and B-15) fractured outside the weld bead zone. Specimens B-21 and B-23 had oxide particles at the origin while B-22 contained no apparent material discrepancy.

A valid comparison of fatigue strengths of ZE41A-T5 and AZ91-T6 could not be made. No bending fatigue tests of AZ91-T6 were conducted in this test program. Previously obtained data on AZ91-T6 was questionable with respect to several important test parameters and was unsuitable for making a sound technical comparison of the fatigue strengths of the two alloys. However, the fatigue testing of the ZE41A-T5 material indicates the current fatigue design allowable stress of $\pm$1000 psi currently used for AZ91C-T6 transmission housings is applicable and is conservative for ZE41A-T5.

FATIGUE CRACK PROPAGATION

The primary objectives of the fatigue crack propagation testing were:

1. Compare the fatigue crack growth characteristics of ZE41A-T5 with AZ91C-T6.

2. Determine if weld repair is detrimental to fatigue crack growth.

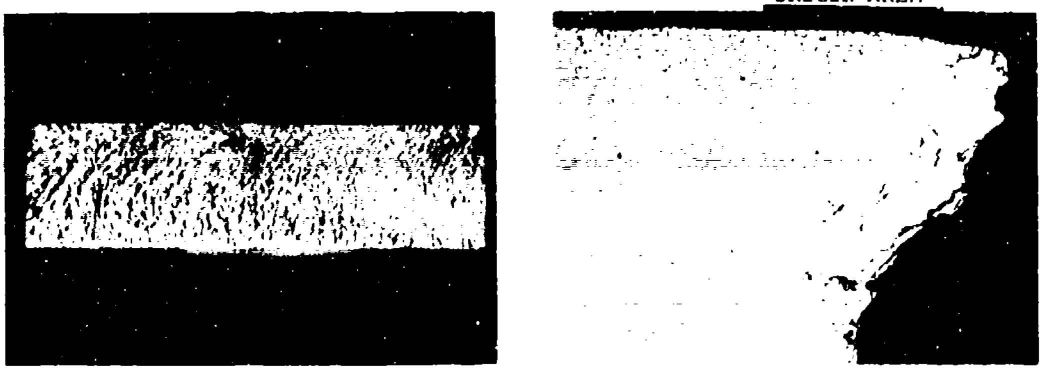
3. Determine if a difference exists in the fatigue crack growth characteristics of material removed from thick and thin sections of castings.

Test Specimen Configuration and Preparation

Thirty-two fatigue crack propagation specimens, 16 of ZE41A-T5 and 16 of AZ91C-T6, were fabricated from large size castings as shown in Figure 1. For each alloy, specimens were fabricated from material removed from thick and thin sections of the castings. Both unwelded and welded specimens were tested. The proportions of these compact tension type specimens were generally in accordance with the recommendations of ASTM Test Method E399-70T. The welded specimens were cut from the casting to orient the weld at the center of the crack starter notch (see Figure 1) such that the crack would tend to propagate within the band of weld metal.

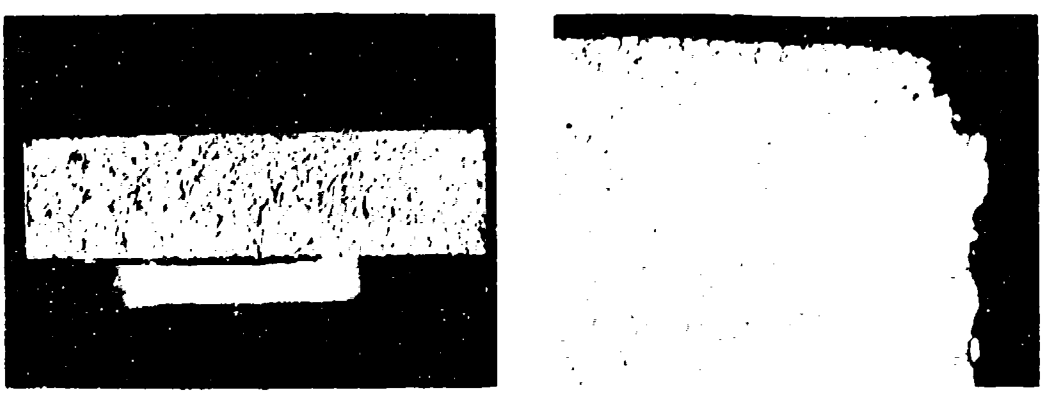
FRACTURE SURFACE

ORIGIN AREA



4X SPECIMEN B-1 60X

4X SPECIMEN B-2 60X



4X SPECIMEN B-3 6

Figure 10. Origin Location and Microstructure Fatigue Test Specimens B-1, B-2, B-3

FRACTURE SURFACE

ORIGIN AREA

4X

B-4

60X

4X

B-5

60X

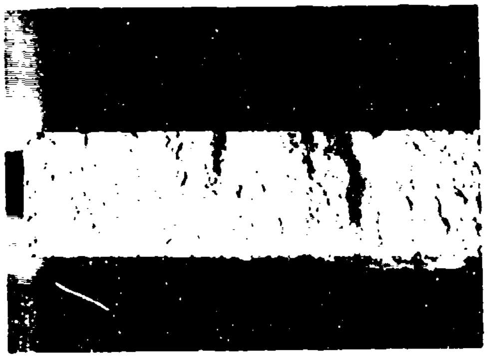
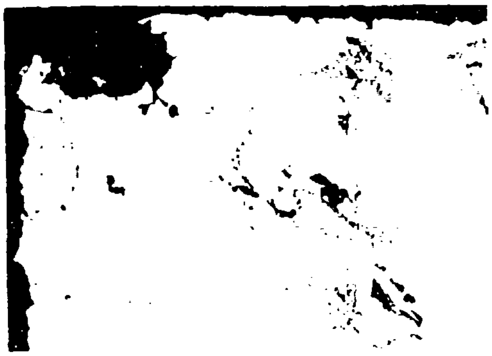
B-6

60X

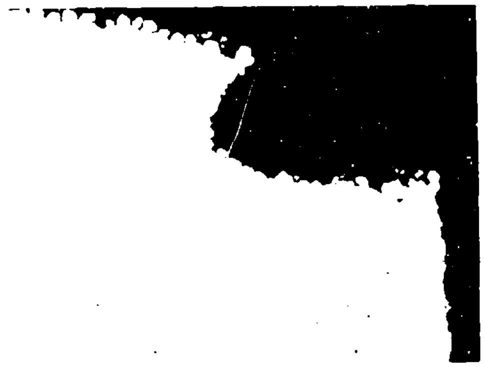
Figure 11. Origin Location and Microstructure of Fatigue Test Specimens B-4, B-5, B-6

FRACTURE SURFACE

ORIGIN AREA

4X B-7 60X

4X 60X

B-8

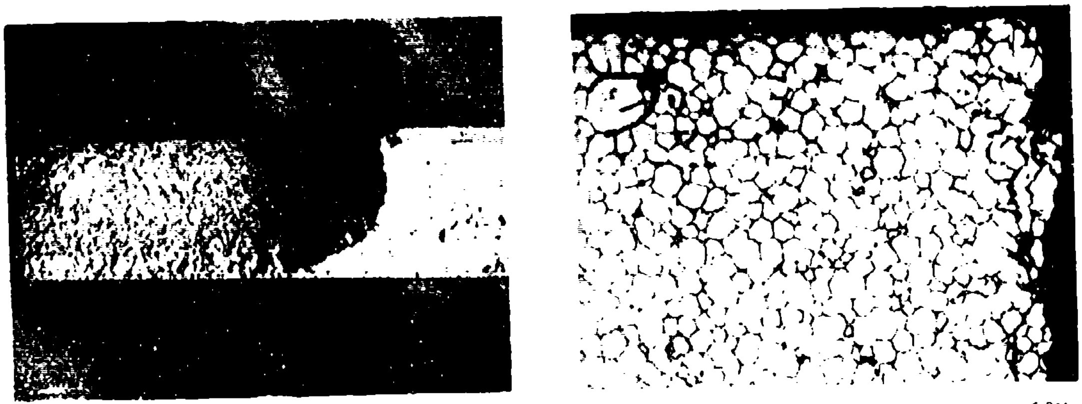

4X 60X

B-9

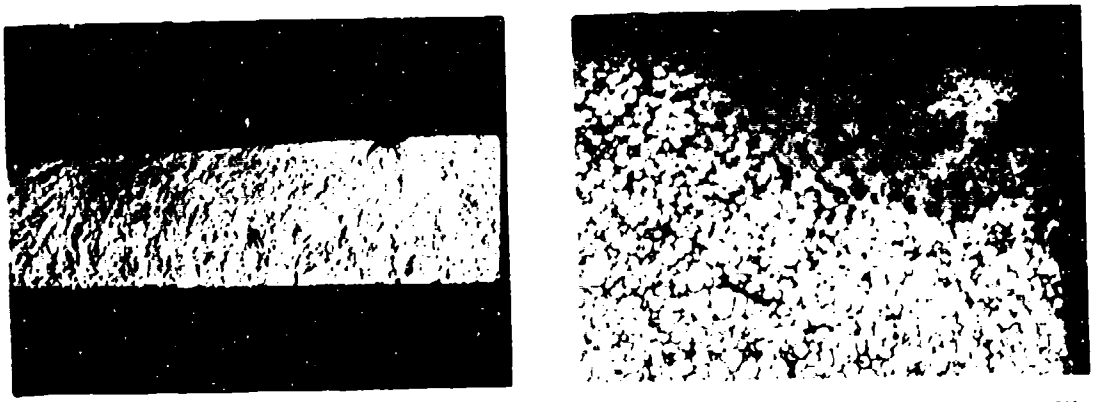
Figure 12. Origin Location and Microstructure of Specimens B-7, B-8, B-9

FRACTURE SURFACE

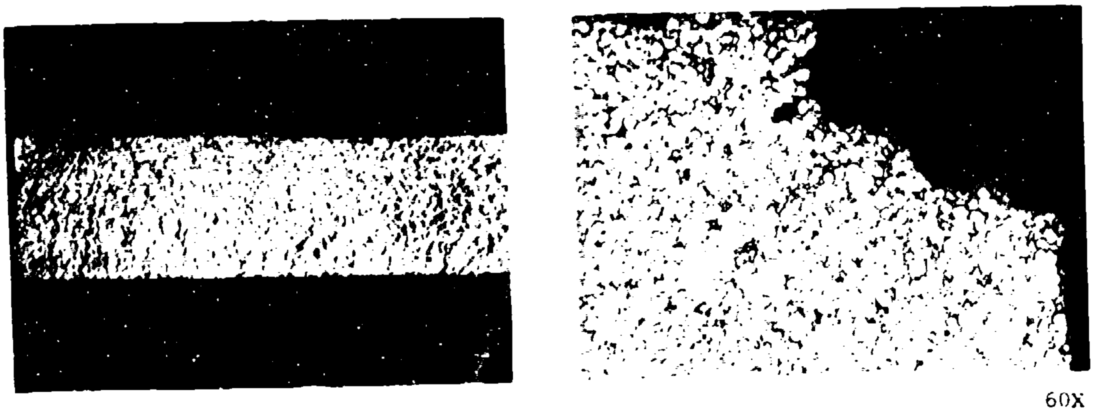
T301-10147-1
ORIGIN AREA



4X B-10 60X



4X B-11 60X



4X B-12 60X

Figure 13. Origin Location and Microstructure of Specimens B-10, B-11, B-12

FRACTURE SURFACE

T301-10147-1
ORIGIN AREA

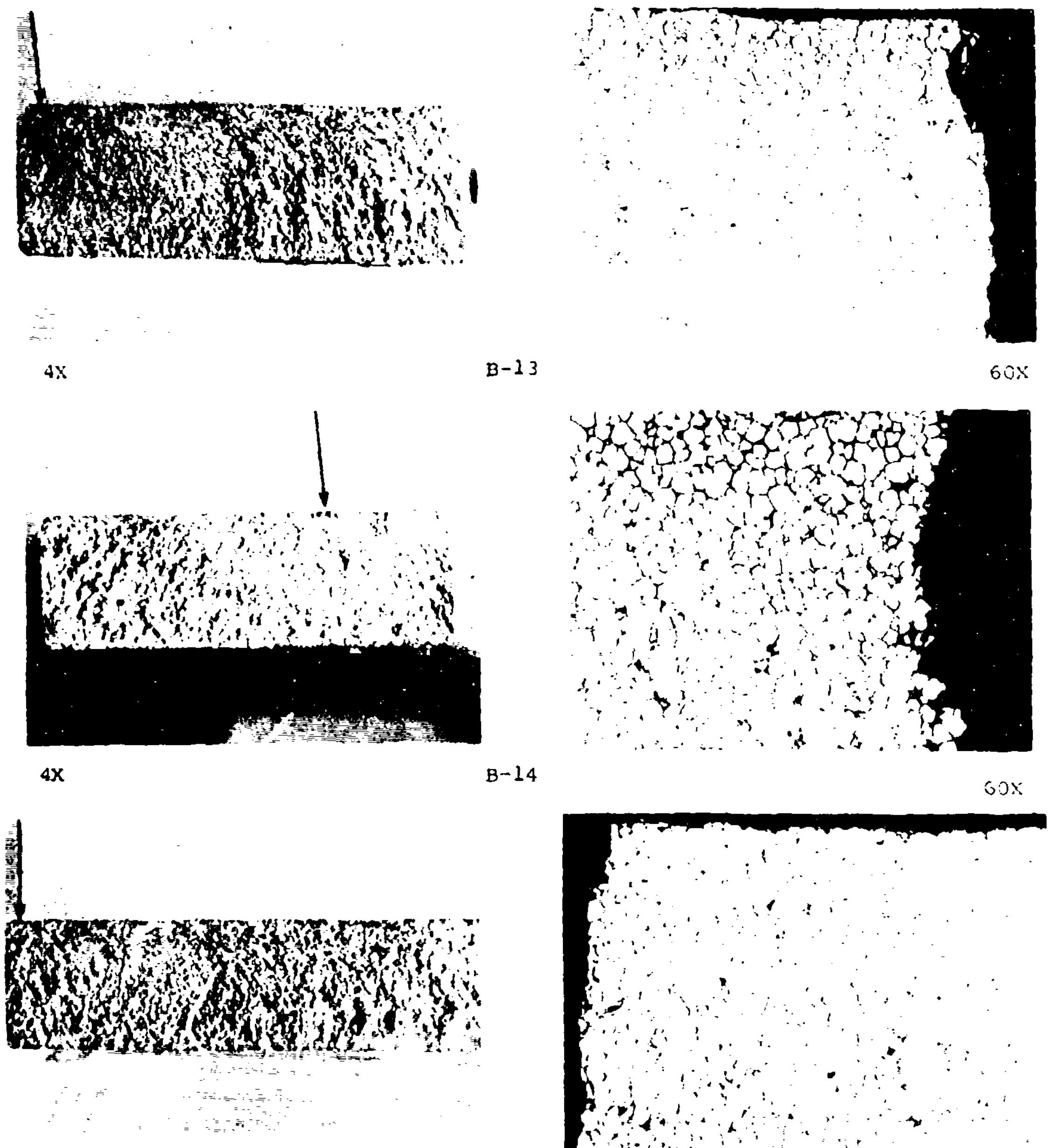


Figure 14. Origin Location and Microstructure of Welded Specimens B-13, B-14, B-15

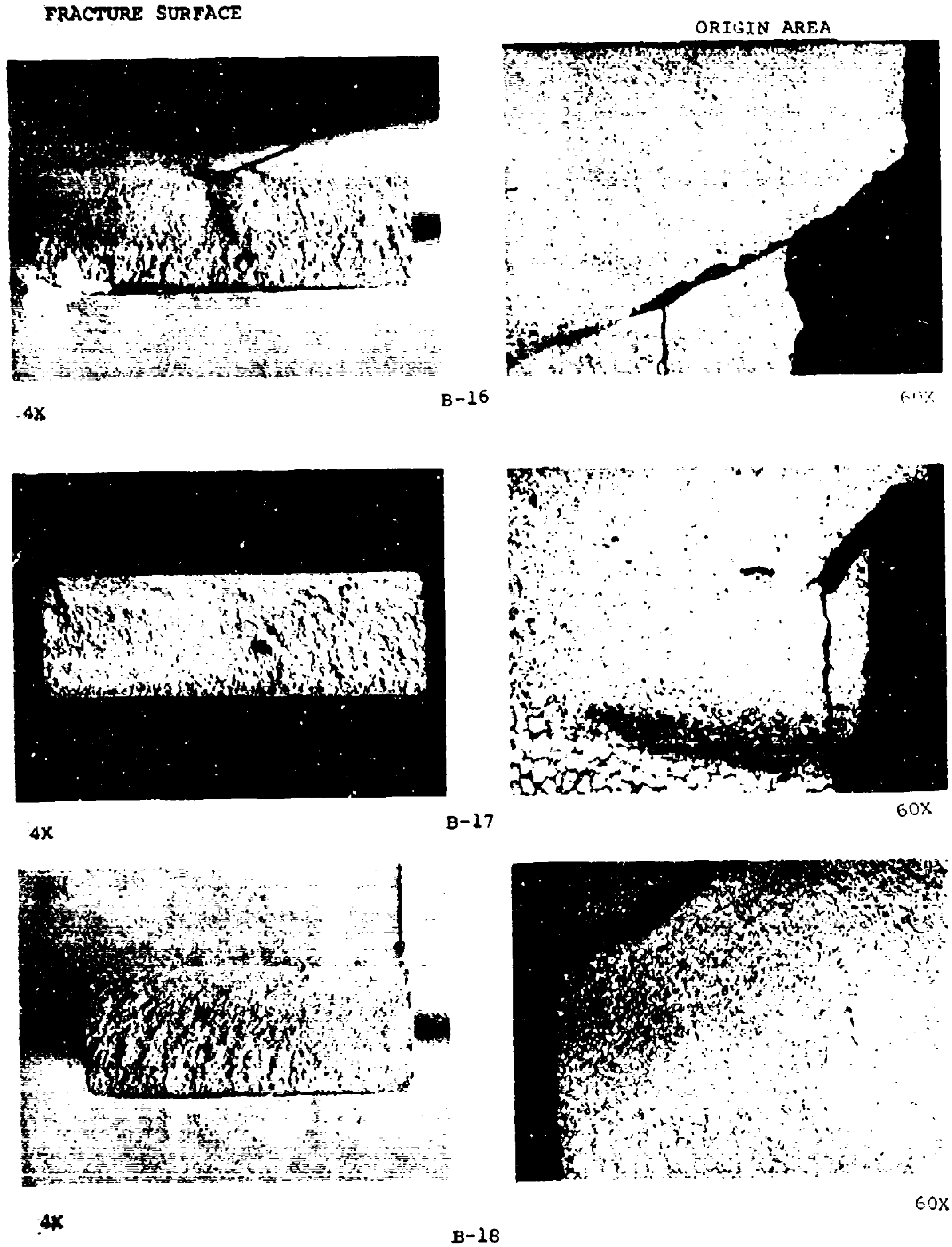


Figure 15. Origin Location and Microstructure of Welded Specimens B-16, B-17, B-18

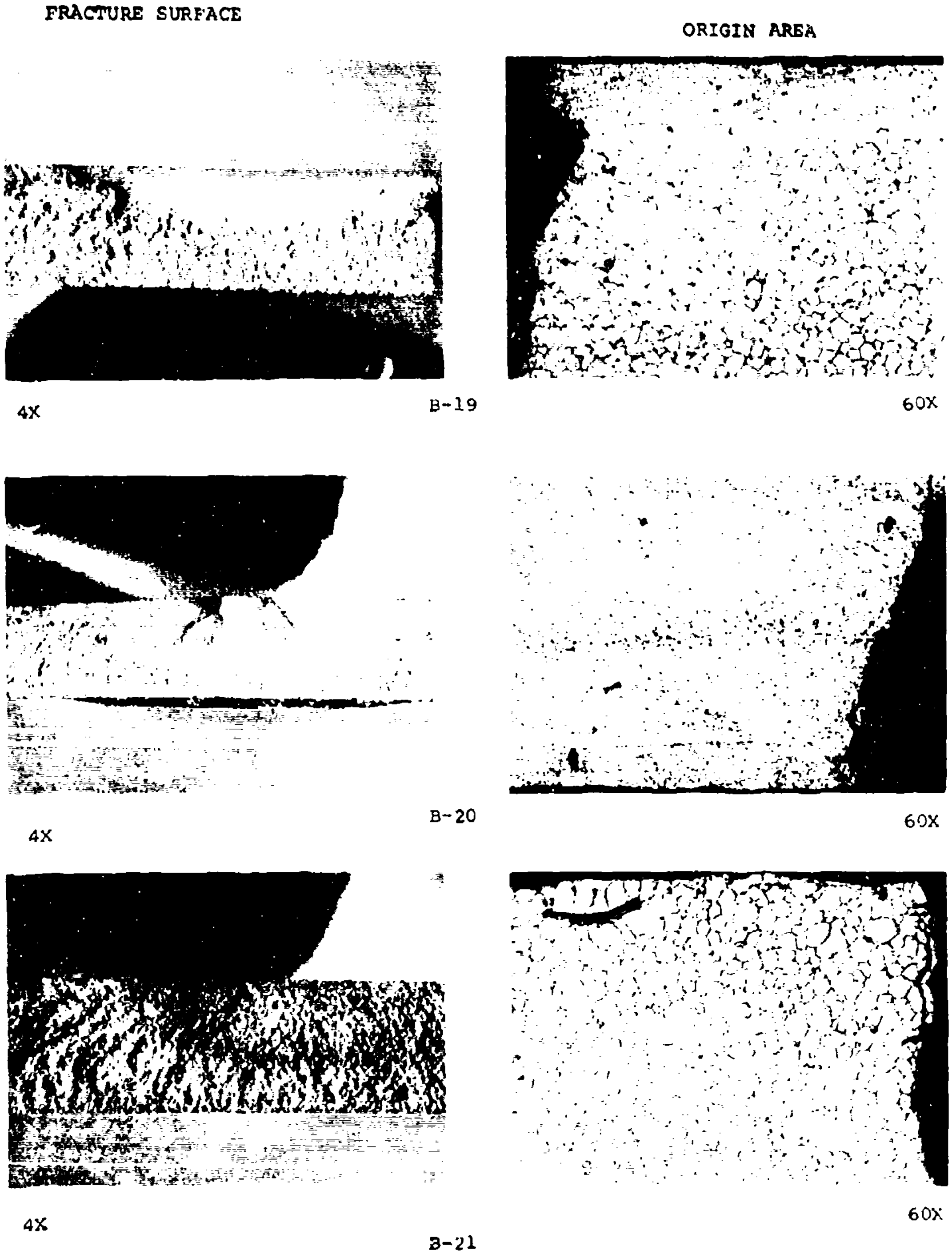


Figure 16. Origin Location and Microstructure of Welded Specimens B-19, B-20, B-21

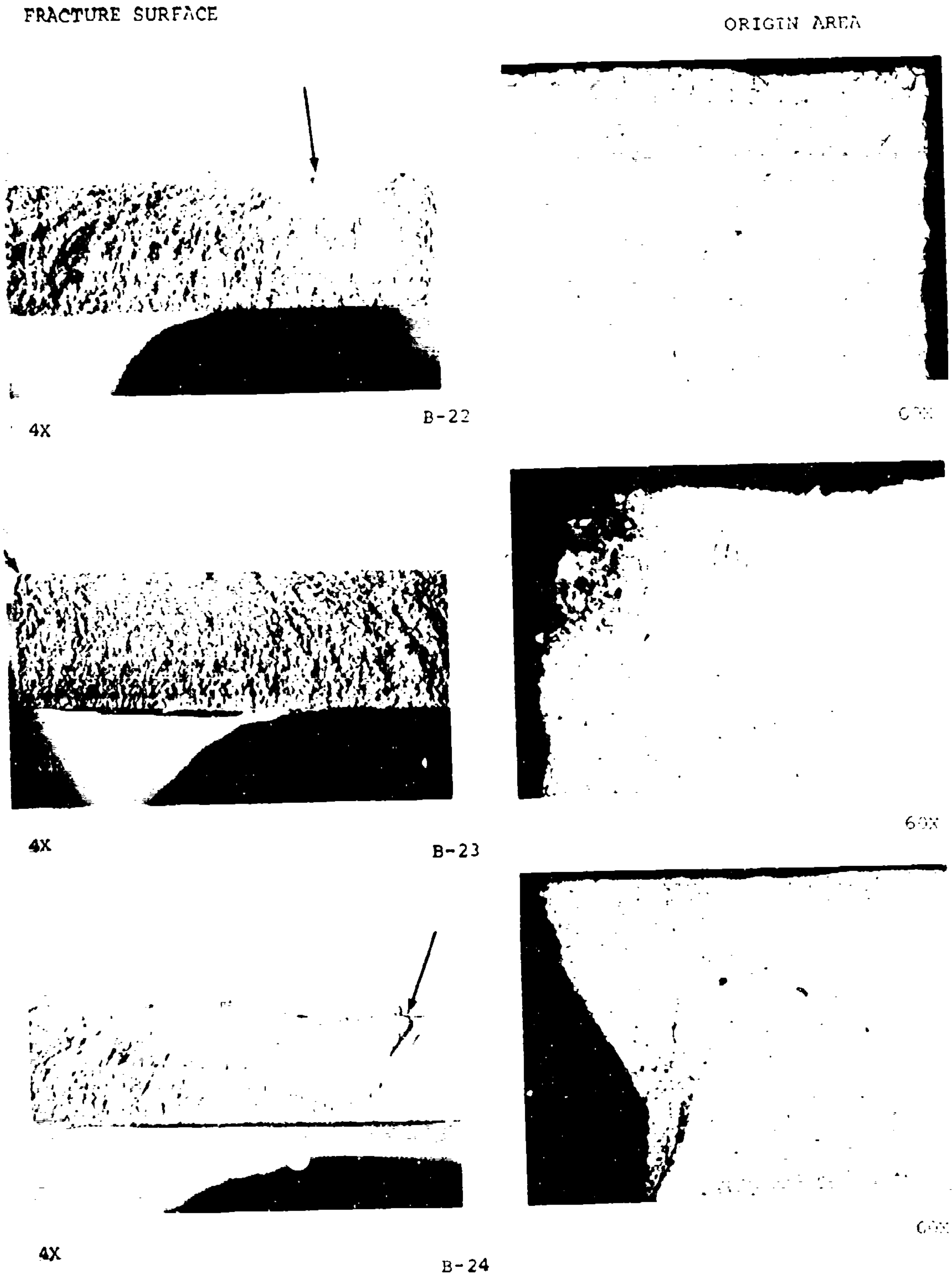


Figure 17. Origin Location and Microstructure of Welded Specimens B-22, B-23, B-24

Details of the material processing, including welding, are discussed in the Material section.

In order to measure crack growth, a grid consisting of approximately 40 lines with a nominal spacing of 0.040 inch was photographically applied to one side of the specimens. A typical specimen with the grid installed is shown in Figure 18.

Test Procedure and Test Setup

Table VI contains a matrix of the fatigue crack propagation specimens. Because of machining errors, 27 specimens were tested rather than 32 as originally planned.

The fatigue crack propagation tests were conducted in air at room temperature. A stress ratio of 0.714, representing the anticipated relationship of steady and alternating stresses in service, was used in these tests. Loads were applied at 10 Hz in the test setup as shown in Figure 19. The test machine contained a load cell in series with the specimen. Load control was provided to permit no greater than ±1.5 percent variation of the cyclic range of load for the duration of each test. In cases where precracking loads higher than the test crack propagation loads were required, care was taken to step down to the test loads in small increments and to let the crack grow to a length such that the prior load would not influence the crack growth data.

Crack growth was monitored visually by observing the intersection of the crack front with the grid lines previously described. Dye penetrant (type MIL-I-25135, Spotcheck SKL-HF Penetrant) and optical magnification of various power (15X and 45X) were used as aids in following the crack. Periodic checks were made to insure that cracking was progressing uniformly on both sides of the specimen. In no case was more than 0.04 inch difference in the crack lengths observed from one side of the specimen to the other.

Basic crack growth data, consisting of crack length and number of cycles, was analyzed using the techniques of fracture mechanics. A computer program was used to calculate the fracture mechanics parameters of stress intensity range, ΔK, and crack growth rate, $\Delta a/\Delta N$. Tables VII and VIII present the data which were used to prepare Figures 21 through 28. The stress intensity range was calculated using the following expression which is found in Reference 3.

$$\Delta K = \frac{\Delta P}{BW^{1/2}}\left[29.6\left(\frac{a}{W}\right)^{1/2} - 185.5\left(\frac{a}{W}\right)^{3/2} + 655.7\left(\frac{a}{W}\right)^{5/2} - 1017.0\left(\frac{a}{W}\right)^{7/2} + 638.9\left(\frac{a}{W}\right)^{9/2}\right]$$

where ΔP is the load range, $P_{max} - P_{min}$

Typical Magnesium
Crack Propagation
Specimen
~Failed~

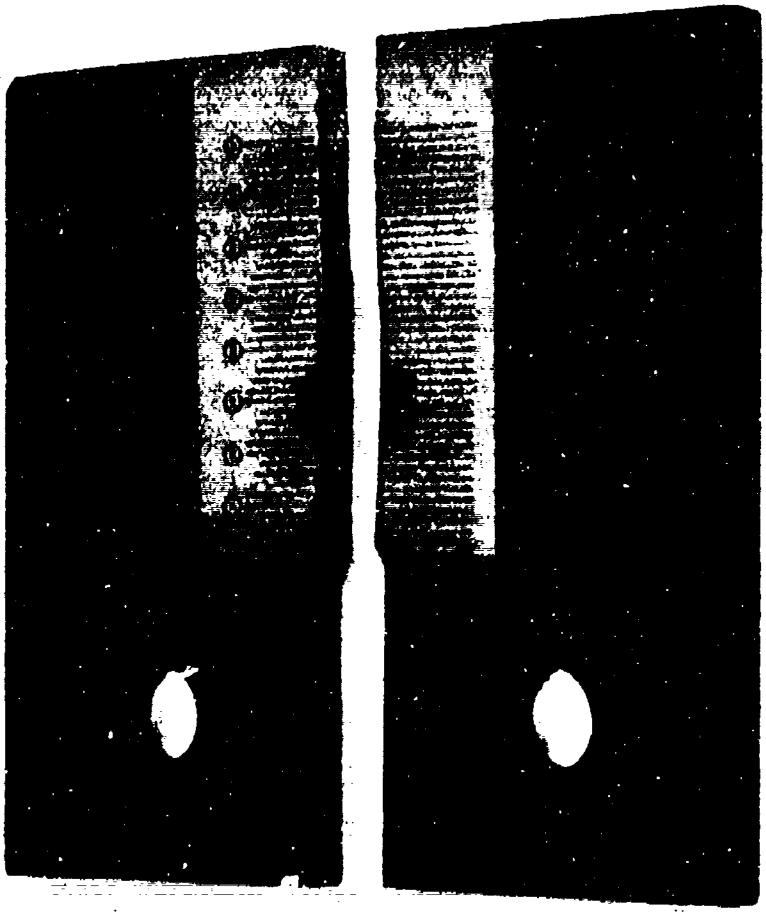


Figure 18. Crack Propagation Specimen with Grid Installed

TABLE VI. SUMMARY OF FATIGUE CRACK PROPAGATION SPECIMENS

SPECIMEN DESIGNATION	ALLOY & CONDITION	CASTING SUPPLIER	CASTING SECTION	CONDITION	REMARKS
C 1	ZE41A-T5	Vendor A	Thin	Nonwelded	
C 2			Thin		①
C 3			Thin		①
C 4			Thin		①
C 5			Thick		
C 6			Thick		
C 7			Thick		
C 8			Thick	Nonwelded	
C 9		Vendor A	Thin	Welded	
C 10		Vendor B	Thin		②
C 11		Vendor A	Thin		
C 12		Vendor B	Thin		②
C 13		Vendor B	Thick		①
C 14		Vendor B	Thick		②
C 15		Vendor A	Thick		
C 16	ZE41A-T5	Vendor B	Thick	Welded	①
C 17	AZ91C-T6	Vendor A	Thin	Nonwelded	
C 18			Thin		
C 19			Thin		
C 20			Thin	Nonwelded	
C 21			Thin	Welded	
C 22			Thin		
C 23			Thin		
C 24			Thin	Welded	
C 25			Thick	Nonwelded	
C 26			Thick		
C 27			Thick		
C 28			Thick	Nonwelded	
C 29			Thick	Welded	
C 30			Thick		
C 31			Thick		
C 32	AZ91C-T6	Vendor A	Thick	Welded	

① Not tested, machining error

② Reduced size specimen, shown in Figure 29

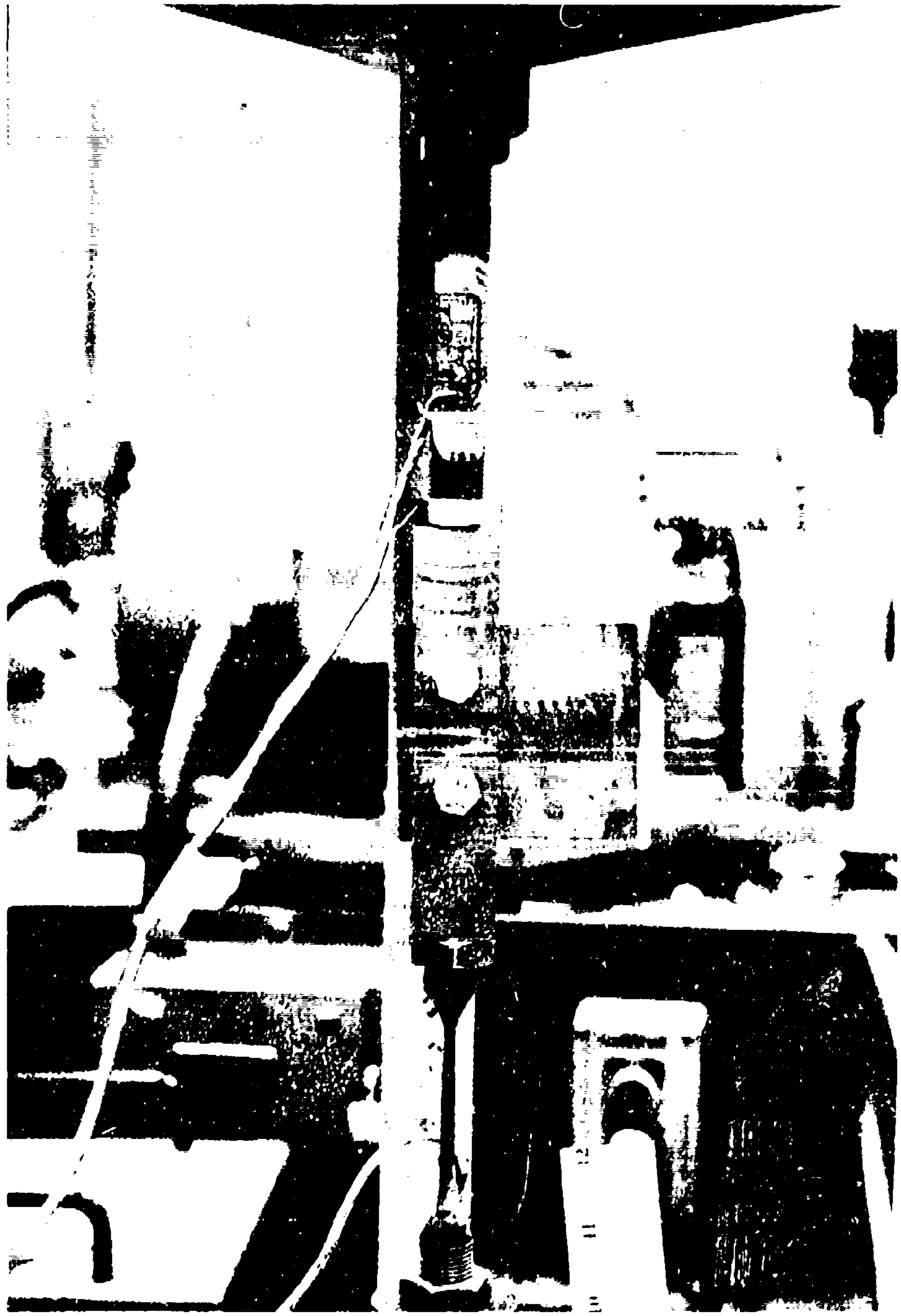


Figure 19. Crack Propagation Setup

Figure 29 indicates the relation of the above dimensional parameters to specimen geometry. All fatigue crack propagation specimens except C-10, C-12, and C-14 were fabricated to the geometry shown in Figure 1. Specimens C-10, C-12, and C-14 were of the geometry of Figure 29.

Test Results

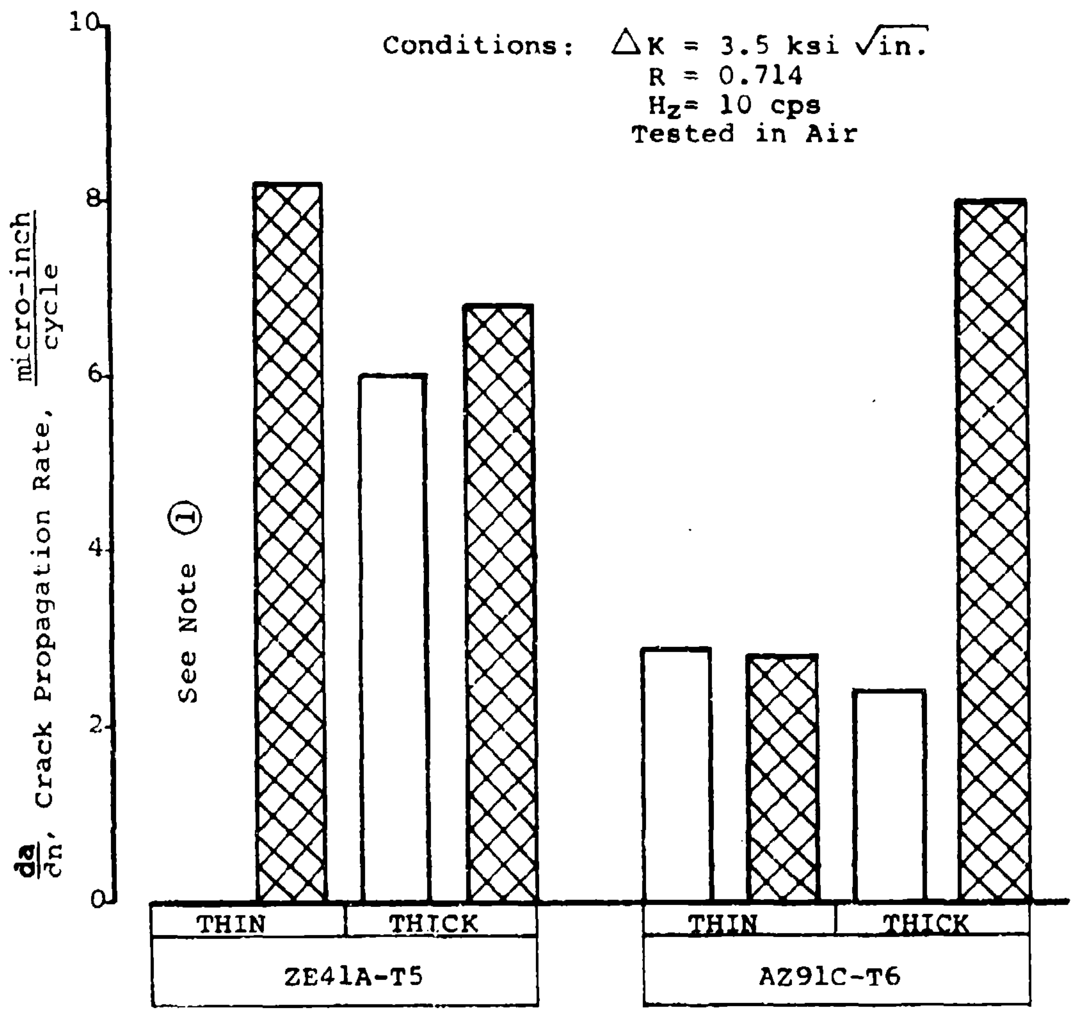
The results of the fatigue crack propagation testing are summarized in Figure 20 which shows the relative crack growth rates for various conditions of the two alloys. Detailed data are contained in Tables VII and VIII and displayed as plots of stress intensity range versus crack growth rate in Figures 21 through 28.

For material in the unwelded condition, AZ91C-T6 (Figures 25 and 26) exhibited slower fatigue crack growth than ZE41A-T5 (Figures 20 and 22). This difference is attributed in part to differences in the microstructure of the two alloys. It should also be noted that yield and elongation values obtained for the AZ91C-T6 material in this program are not typical of average values obtained by testing samples cut from actual transmission housings. Yield values determined in this program were lower while elongations were higher than those typically obtained from actual transmission housings.

For the ZE41A-T5 material, no difference was observed between the crack growth rates of welded (Figures 23 and 24) and unwelded material (Figures 21 and 22). In the case of the AZ91C-T6 casting, the welded specimens (Figure 28) utilizing material from a thick section showed a faster crack growth rate than the unwelded material (Figure 26). No significant difference was seen in the crack growth rates of welded (Figure 27) and unwelded (Figure 25) AZ91C-T6 material removed from thin sections of the castings.

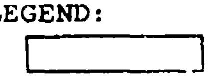
The ZE41A-T5 material showed no significant differences in the crack growth rates of specimens removed from thick (Figures 22 and 24) and thin (Figures 21 and 23) sections of the castings. Unwelded AZ91C-T6 specimens exhibited the same trend.

In all cases, the fatigue crack propagated normal to the applied load. For the welded specimens, the crack remained within the band of weld metal, and metallurgical examination indicated that the band of weld metal extended completely through the thickness of the specimen.



NOTE ① : Limited data at this condition does not warrant a comparison

LEGEND:



Nonwelded

Welded

Figure 20. Crack Growth Comparisons for Magnesium Alloys at a Constant Stress Intensity Value

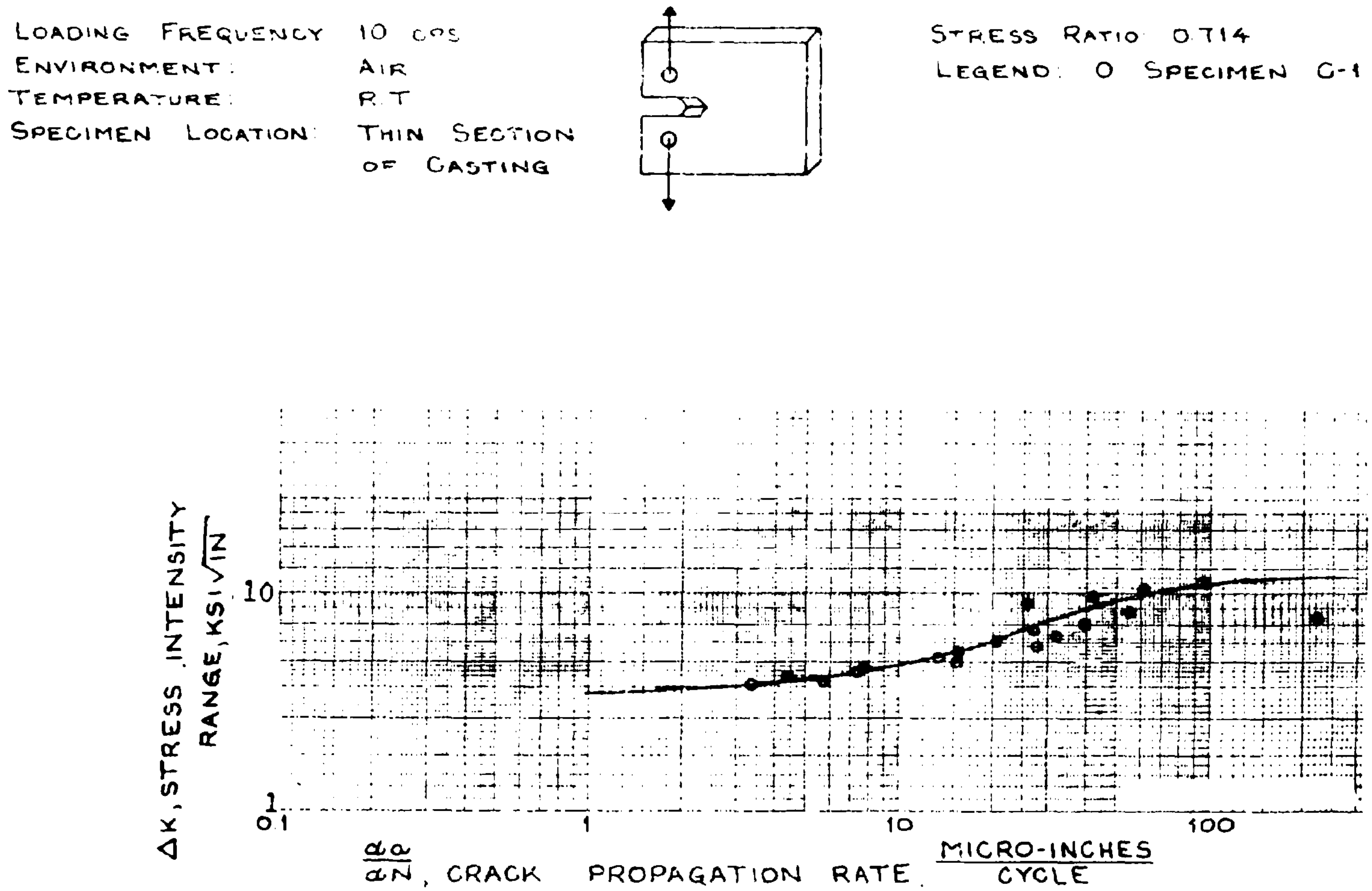


Figure 21. Fatigue Crack Growth Rate for ZE41A Magnesium Casting Crack Propagation Testing of Nonwelded Specimens

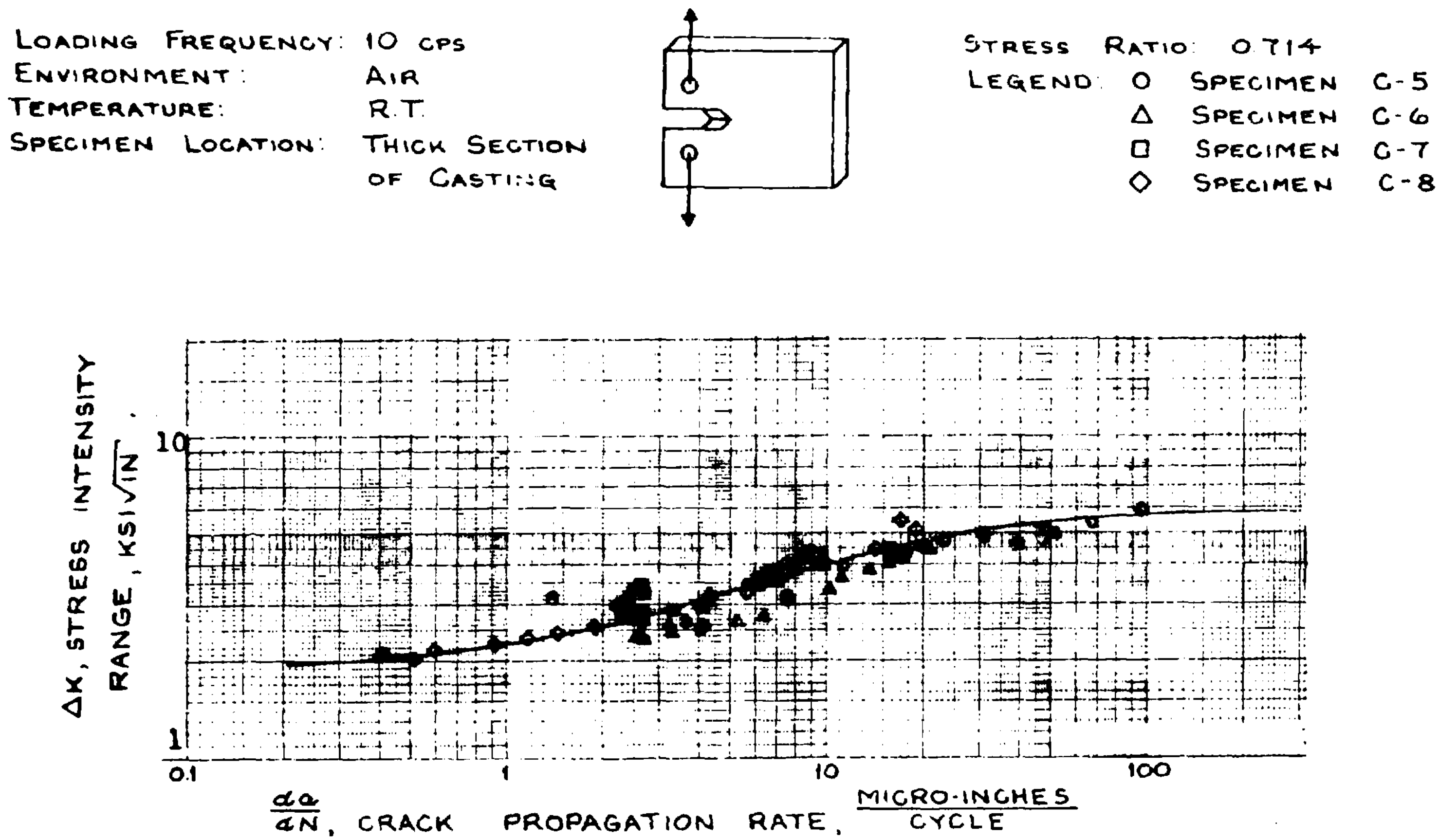


Figure 22. Fatigue Crack Growth Rate for ZE41A Magnesium Casting Crack Propagation Testing of Nonwelded Specimens

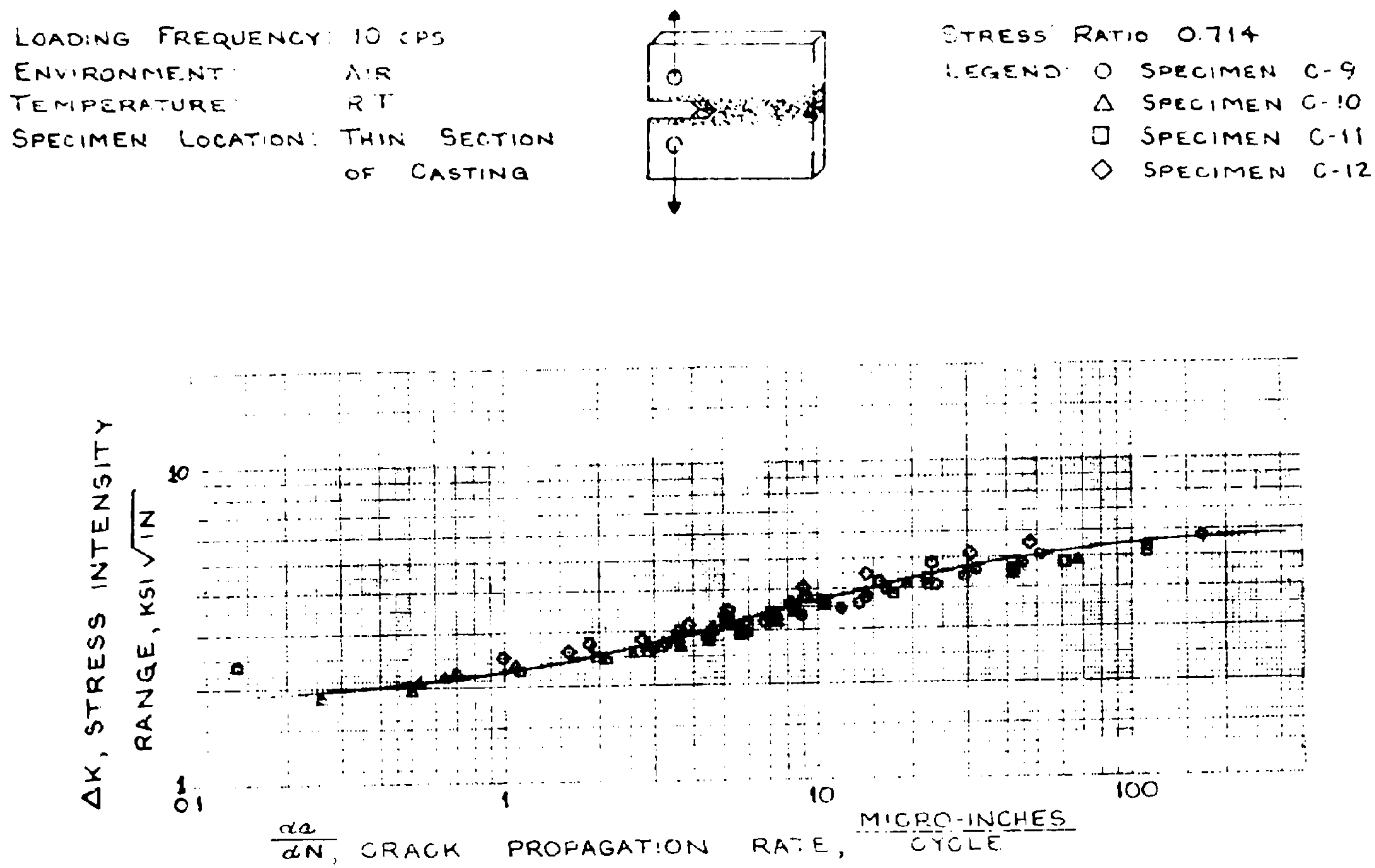


Figure 2[illegible]. Fatigue Crack Growth Rate for ZE41[illegible] Magnesium Casting Crack Propagation Testing of Welded Specimens

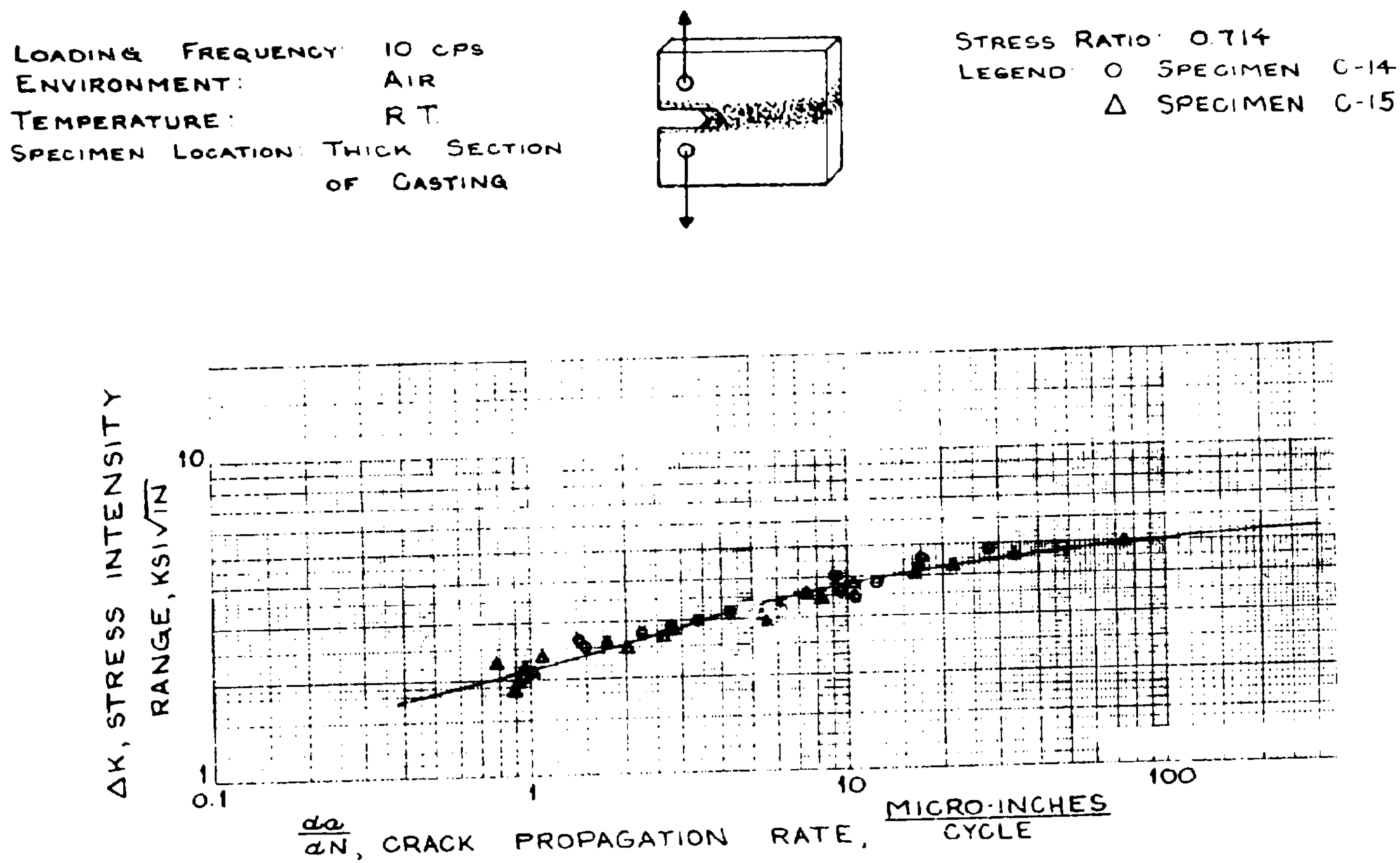


Figure 24. Fatigue Crack Growth Rate for ZE41A Magnesium Casting Crack Propagation Testing of Welded Specimens

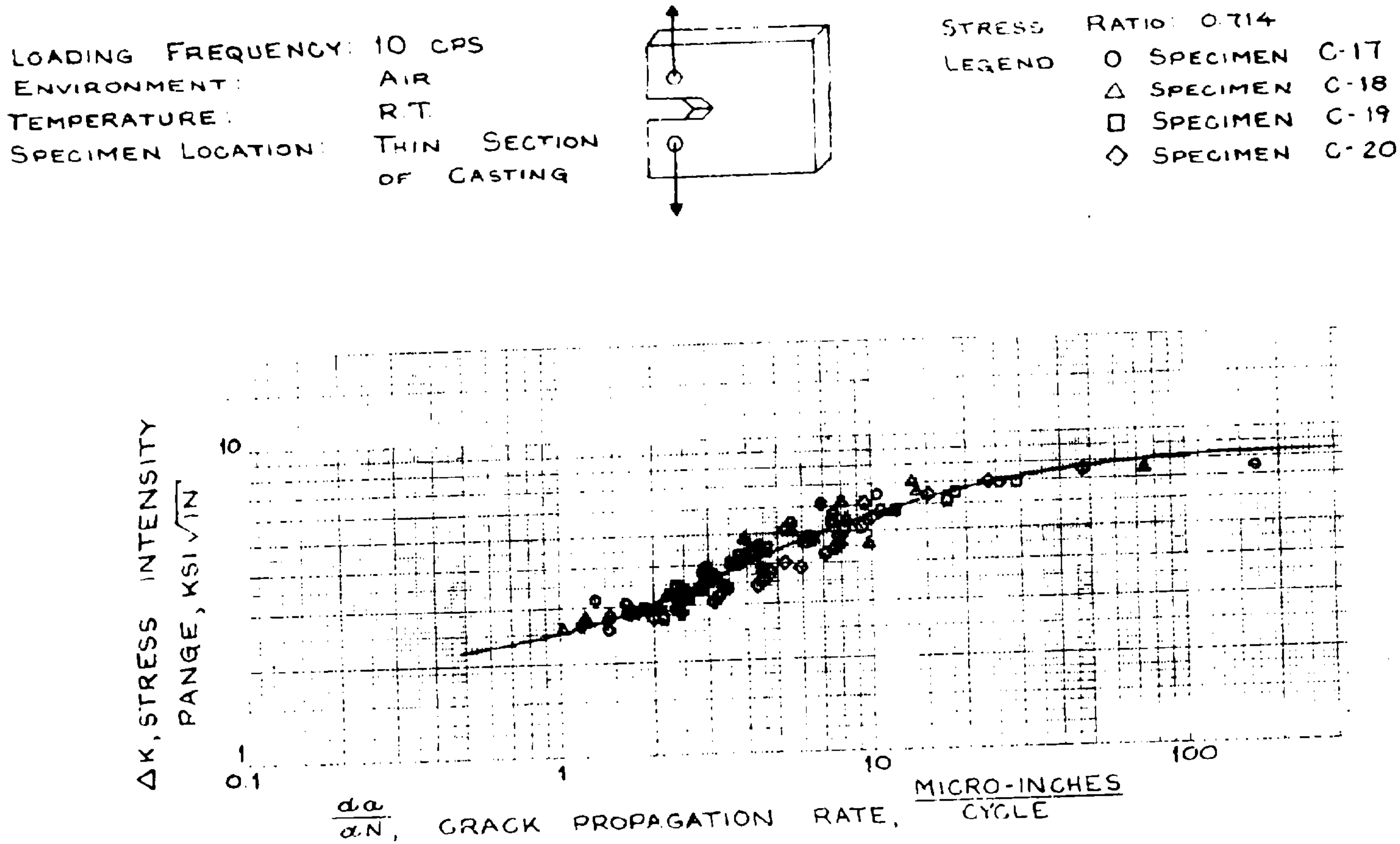


Figure 25 Fatigue Crack Growth Rate for AZ91C Magnesium Casting Crack Propagation Testing of Nonwelded Specimens

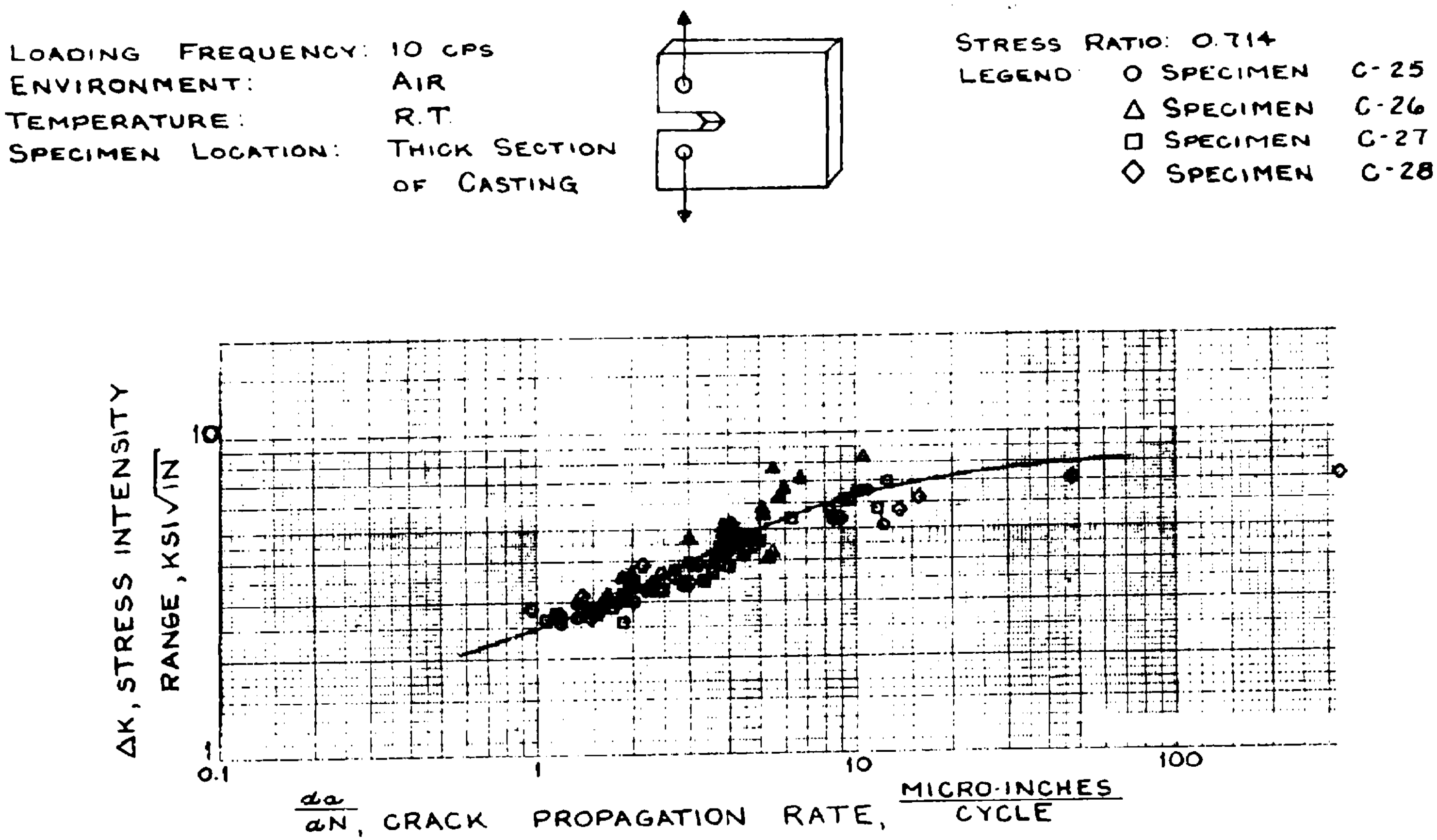


Figure 26. Fatigue Crack Growth Rate for AZ91C Magnesium Casting Crack Propagation Testing of Nonwelded Specimens

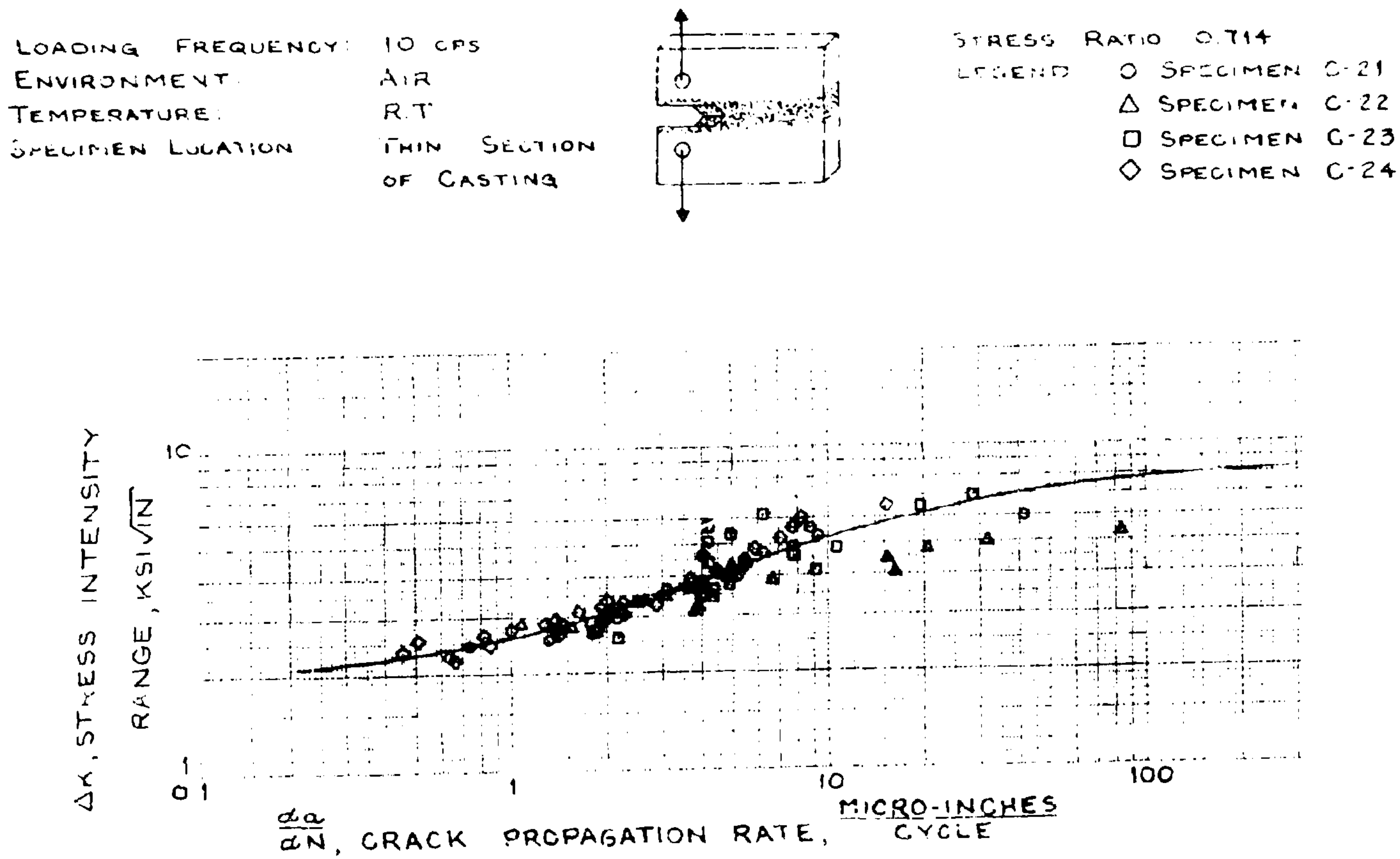


Figure 27. Fatigue Crack Growth Rate for AZ91 Magnesium Casting Crack Propagation Testing of Welded Specimens

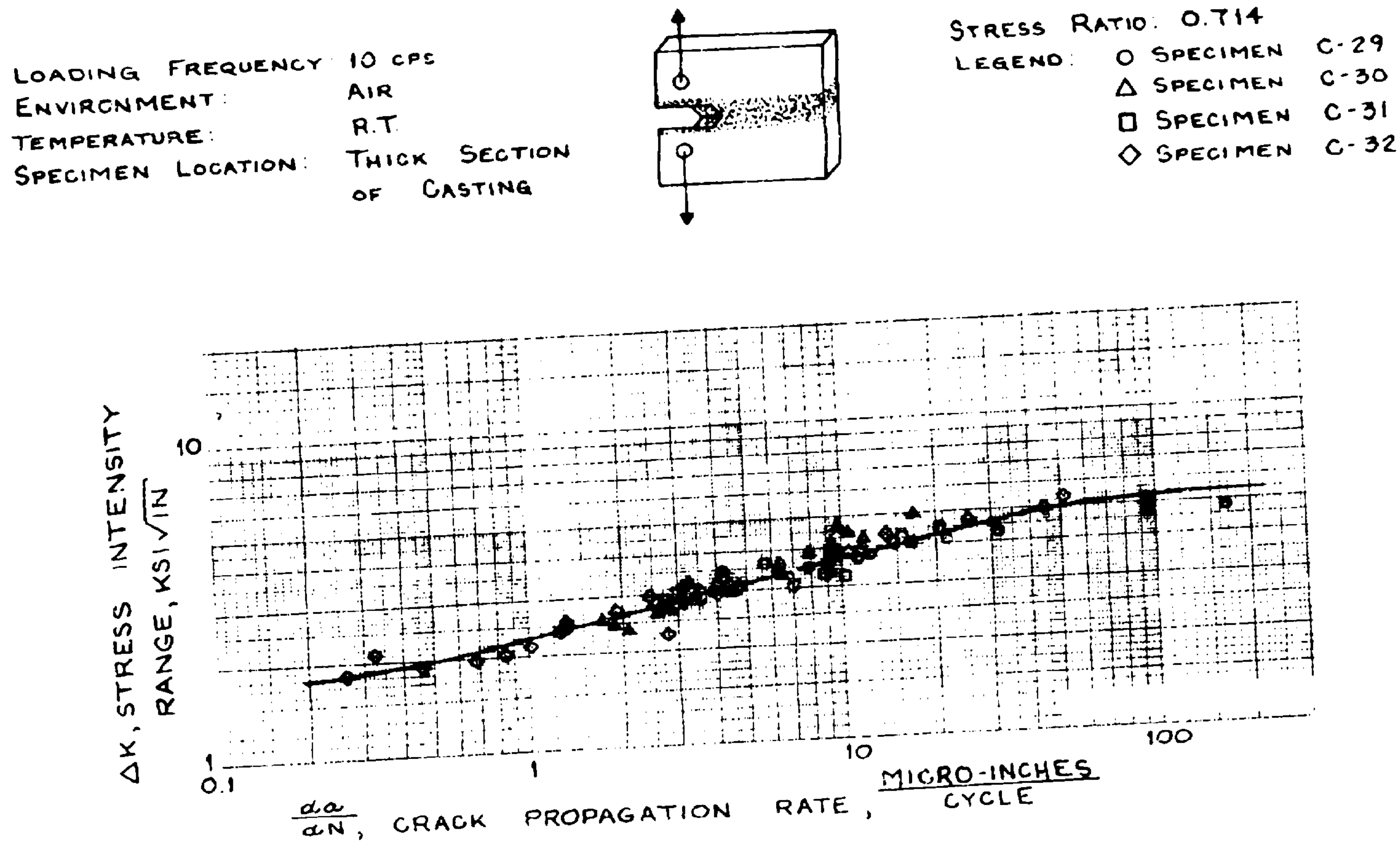
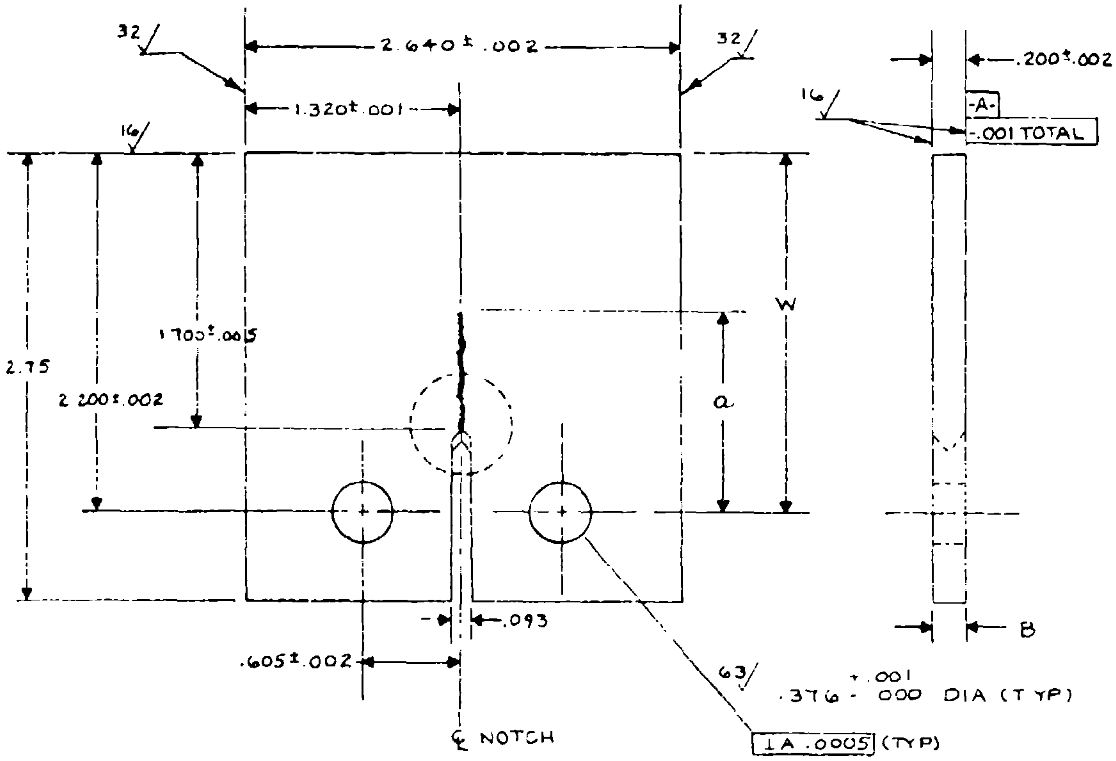


Figure 28. Fatigue Crack Growth Rate for AZ91C Magnesium Casting Crack Propagation Testing of Welded Specimens



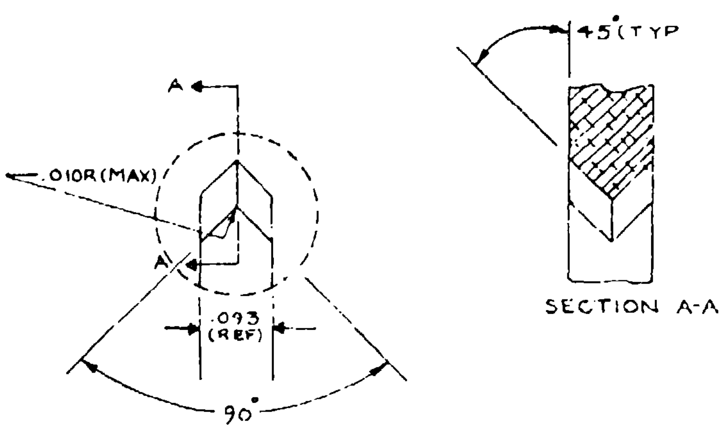


Figure 29. Modified Crack Propagation
Specimen for ZE41A-T5 Welded Magnesium

NOMENCLATURE - TABLE VII and TABLE VIII

The following nomenclature is applicable to the crack propagation data contained in Tables VII and VIII.

P_{MAX}	=	Maximum applied load (steady + alternating), lb
P_{MIN}	=	Minimum applied load (steady - alternating), lb
A_O	=	Initial crack length measured from centerline of holes to line at which first test reading was taken, in.
N_O	=	Initial number of cycles corresponding to crack length, A_O
B	=	Specimen thickness (Reference Figure 29), in.
W	=	Distance measured from centerline of holes to back of specimen (Reference Figure 29), in.
A	=	Crack length measured from centerline of holes to crack tip, in.
N	=	Total number of applied cycles
DELA	=	Change in crack length, in.
DELN	=	Change in applied cycles
K_{MAX}	=	Maximum stress intensity factor, psi $\sqrt{in.}$
DELK	=	Stress intensity range, psi $\sqrt{in.}$
DADN	=	Crack propagation rate, in./cycle

TABLE VIII. [illegible] CRACK PROPAGATION [illegible] AT [illegible] MAGNESIUM [illegible] IN [illegible]

C- 1:ZE41A:NON-WELDED:THIN SECTION OF CASTING:R=0.71:10 CPS

PMAX	PMIN	AO	NO	B	W
490.	250.	0.67930	0.	0.20050	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.71830E 00	12060.	0.40000E-01	12060.	8834.98	2524.28	0.33167E-05
0.75830E 00	19020.	0.40000E-01	6960.	9398.05	2599.44	0.57471E-05
0.79830E 00	28260.	0.40000E-01	9240.	9394.06	2683.73	0.43290E-05
0.83830E 00	33780.	0.40000E-01	5520.	9718.22	2776.64	0.72464E-05
0.87830E 00	39000.	0.40000E-01	5220.	10072.30	2877.80	0.76628E-05
0.91830E 00	41640.	0.40000E-01	2640.	10454.18	2986.91	0.15152E-04
0.95830E 00	44640.	0.40000E-01	3000.	10863.59	3103.88	0.13333E-04
0.99830E 00	47280.	0.40000E-01	2640.	11300.66	3228.76	0.15152E-04
0.10383E 01	48720.	0.40000E-01	1440.	11766.68	3361.91	0.27777E-04
0.10783E 01	50700.	0.40001E-01	1980.	12263.66	3503.90	0.20202E-04
0.11183E 01	51960.	0.40000E-01	1260.	12794.55	3655.59	0.31746E-04
0.11583E 01	53460.	0.40000E-01	1500.	13363.60	3818.17	0.26667E-04
0.11983E 01	54480.	0.40000E-01	1020.	13976.17	3993.19	0.39216E-04
0.12383E 01	54660.	0.40000E-01	180.	14639.04	4182.58	0.22222E-03
0.12783E 01	55380.	0.40000E-01	720.	15360.16	4388.62	0.55556E-04
0.13183E 01	56940.	0.40000E-01	1560.	16149.00	4614.00	0.25641E-04
0.13583E 01	57900.	0.40000E-01	960.	17016.75	4861.93	0.41667E-04
0.13983E 01	58560.	0.40000E-01	660.	17976.12	5136.04	0.60606E-04
0.14383E 01	58980.	0.40000E-01	420.	19041.27	5440.36	0.95238E-04

TABLE VII - Continued

C-5:ZE41A:NON-WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	A0	N0	B	W
490.	350.	0.67130	0.	0.20080	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.71130E 00	9780.	0.40000E-01	9780.	8779.21	2508.35	0.40900E-05
0.75130E 00	19500.	0.40000E-01	9720.	9336.13	2581.75	0.41152E-05
0.79130E 00	30540.	0.40000E-01	11040.	9325.24	2664.35	0.55232E-05
0.83130E 00	48120.	0.40000E-01	17580.	9644.73	2755.64	0.22753E-05
0.87130E 00	64260.	0.40000E-01	16140.	9993.36	2855.25	0.24783E-05
0.91130E 00	74220.	0.40000E-01	9960.	10369.90	2962.83	0.40151E-05
0.95130E 00	79560.	0.40000E-01	5340.	10773.82	3078.23	0.74900E-05
0.99130E 00	84900.	0.40000E-01	5340.	11205.41	3201.55	0.74906E-05
0.10313E 01	101280.	0.40000E-01	16380.	11665.55	3333.01	0.24420E-05
0.10713E 01	108360.	0.40000E-01	7080.	12156.08	3473.17	0.56497E-05
0.11113E 01	113880.	0.40001E-01	5520.	12680.01	3622.86	0.72465E-05
0.11513E 01	119100.	0.40000E-01	5220.	13241.27	3783.22	0.75629E-05
0.11913E 01	122640.	0.40000E-01	3540.	13844.80	3955.66	0.11293E-04
0.12313E 01	124980.	0.40000E-01	2340.	14497.30	4142.09	0.17094E-04
0.12713E 01	127260.	0.40000E-01	2280.	15206.52	4344.72	0.17544E-04
0.13113E 01	129300.	0.40000E-01	2040.	15981.75	4566.21	0.19608E-04
0.13513E 01	130620.	0.40000E-01	1320.	16833.56	4809.59	0.30303E-04
0.13913E 01	131460.	0.40000E-01	840.	17774.43	5078.41	0.47619E-04
0.14313E 01	132060.	0.40000E-01	600.	18818.46	5376.70	0.66657E-04

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TABLE VII - Continued

C-6:ZE41A:NON-WELDED:THICK SECTION OF CASTING:R=0.7,14.10 CPS

PMAX	PMIN	AO	NO	B	M
455.	325.	0.67040	0.	0.20097	2.50000

A	N	DELA	DELN	KMAX	DELK	DAUN
0.71040E 00	15300.	0.40000E-01	15300.	8140.22	2325.78	0.25144E-05
0.75040E 00	30960.	0.40000E-01	15660.	8377.89	2393.68	0.25543E-05
0.79040E 00	43140.	0.40000E-01	12180.	8645.46	2470.13	0.32841E-05
0.83040E 00	55560.	0.40000E-01	12420.	8941.30	2554.66	0.32206E-05
0.87040E 00	63120.	0.40000E-01	7560.	9264.12	2646.89	0.52910E-05
0.91040E 00	67360.	0.40000E-01	4240.	9612.87	2746.53	0.64102E-05
0.95040E 00	84120.	0.40000E-01	14760.	9987.09	2853.45	0.27100E-05
0.99040E 00	94080.	0.40000E-01	9960.	10386.93	2967.70	0.40161E-05
0.10304E 01	103440.	0.40000E-01	9360.	10813.19	3089.48	0.42735E-05
0.10704E 01	112500.	0.40000E-01	9360.	11267.73	3219.35	0.42735E-05
0.11104E 01	116760.	0.40000E-01	3960.	11753.04	3359.01	0.10101E-04
0.11504E 01	122460.	0.40000E-01	5700.	12272.93	3506.55	0.70175E-05
0.11904E 01	126060.	0.40000E-01	3600.	12831.94	3666.27	0.11111E-04
0.12304E 01	129000.	0.40000E-01	2940.	13436.24	3838.93	0.13605E-04
0.12704E 01	131580.	0.40000E-01	2580.	14093.02	4026.58	0.15504E-04
0.13104E 01	136140.	0.40000E-01	4560.	14810.73	4231.64	0.87719E-05
0.13504E 01	138060.	0.40000E-01	1920.	15599.23	4456.92	0.20833E-04

TABLE VII - Continued

C-7:ZE41A:NON-WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	AO	NO	B	M
420.	300.	0.99700	0.	0.19960	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.10370E 01	12120.	0.40000E-01	12120.	10117.78	2690.80	0.33003E-05
0.10770E 01	23800.	0.40000E-01	16680.	10544.73	3012.78	0.23981E-05
0.11170E 01	57480.	0.40000E-01	28680.	11000.84	3143.10	0.13947E-05
0.11570E 01	72300.	0.40000E-01	14820.	11489.64	3282.75	0.25991E-05
0.11970E 01	87540.	0.40000E-01	15240.	12015.80	3433.09	0.25247E-05
0.12370E 01	93120.	0.40001E-01	5580.	12585.00	3595.72	0.71686E-05
0.12770E 01	99240.	0.40000E-01	6120.	13204.11	3772.60	0.65359E-05
0.13170E 01	103260.	0.40000E-01	4020.	13881.36	3966.10	0.99502E-05
0.13570E 01	105780.	0.40000E-01	2520.	14626.07	4178.88	0.15873E-04
0.13970E 01	108200.	0.40000E-01	2520.	15449.42	4414.12	0.15873E-04
0.14370E 01	109320.	0.40000E-01	1020.	16363.36	4675.25	0.39216E-04
0.14770E 01	110100.	0.40000E-01	780.	17381.64	4966.18	0.51282E-04

TABLE VII - Continued

C-8:25411:NON-WELDED:THICK SECTION OF CASTING:R=0.71[illegible]

PMAX	PMIN	AO	ND	B	W
385.	275.	0.70520	0.	0.19957	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.74520E 00	77400.	0.40000E-01	77400.	7110.91	2031.69	0.51680E-06
0.78520E 00	175560.	0.40000E-01	98160.	7375.69	2095.91	0.40750E-06
0.82520E 00	243240.	0.40000E-01	67680.	7588.68	2167.05	0.59102E-06
0.86520E 00	287340.	0.40000E-01	44100.	7855.83	2244.81	0.77703E-06
0.90520E 00	322020.	0.40000E-01	34680.	8151.16	2328.91	0.1153[illegible]E-05
0.94520E 00	350220.	0.40000E-01	28200.	8467.18	2419.19	0.14184E-05
0.98520E 00	371340.	0.40000E-01	21120.	8805.04	2515.73	0.1893[illegible]E-05
0.10252E 01	386520.	0.40000E-01	15180.	9165.27	2618.65	0.25350E-05
0.10652E 01	402600.	0.40000E-01	16080.	9549.30	2728.37	0.24876E-05
0.11052E 01	419700.	0.40000E-01	17100.	9959.27	2845.51	0.23392E-05
0.11452E 01	437880.	0.40000E-01	18190.	10398.27	2970.93	0.22002E-05
0.11852E 01	454560.	0.40000E-01	16680.	10870.01	3105.72	0.23981E-05
0.12252E 01	461700.	0.40000E-01	7140.	11379.55	3251.31	0.55022E-05
0.12652E 01	468240.	0.40000E-01	6540.	11932.96	3409.42	0.61162E-05
0.13052E 01	474360.	0.40000E-01	6120.	12537.29	3582.08	0.65359E-05
0.13452E 01	480120.	0.40000E-01	5760.	13200.83	3771.67	0.69444E-05
0.13852E 01	485460.	0.40000E-01	5340.	13933.27	3980.94	0.74906E-05
0.14252E 01	489660.	0.40001E-01	4200.	14745.46	4212.99	0.95240E-05
0.14652E 01	492480.	0.40000E-01	2820.	15649.51	4471.29	0.14184E-04
0.15052E 01	494220.	0.40000E-01	1740.	1[illegible]653.97	4759.71	0.22983E-04
0.15452E 01	496320.	0.40000E-01	2100.	17789.31	5082.66	0.19048E-04
0.15852E 01	498660.	0.40000E-01	2340.	190[illegible].90	5444.83	0.17094E-04
0.16252E 01	499080.	0.40000E-01	420.	2047[illegible].[illegible]5	5851.41	0.9[illegible]233E-04

TABLE VII - Continued

C- 9:ZE41A:WELDED:THIN SECTION OF CASTING:R=0.714:10CPS

PMAX	PMIN	AO	NO	B	W
490.	350.	0.74810	0.	0.20190	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.78810E 00	13500.	0.40000E-01	13500.	9250.28	2642.94	0.29630E-05
0.82810E 00	25680.	0.40000E-01	12180.	9565.72	2733.06	0.32841E-05
0.86810E 00	34620.	0.40000E-01	8940.	9910.15	2831.47	0.44743E-05
0.90810E 00	41400.	0.40000E-01	6780.	10282.41	2937.83	0.58997E-05
0.94810E 00	47400.	0.40000E-01	6000.	10681.98	3051.99	0.66667E-05
0.98810E 00	52800.	0.40000E-01	5400.	11108.97	3173.99	0.74074E-05
0.10281E 01	57360.	0.40000E-01	4560.	11564.28	3304.08	0.87719E-05
0.10681E 01	60720.	0.40000E-01	3360.	12049.68	3442.77	0.11905E-04
0.11081E 01	63720.	0.40000E-01	3000.	12567.92	3590.84	0.13333E-04
0.11481E 01	66540.	0.40000E-01	2820.	13122.89	3749.40	0.14184E-04
0.11881E 01	68940.	0.40000E-01	2400.	13719.71	3919.92	0.16667E-04
0.12281E 01	70620.	0.40000E-01	1680.	14364.46	4104.13	0.23809E-04
0.12681E 01	72000.	0.40000E-01	1380.	15064.94	4304.27	0.28985E-04
0.13081E 01	73260.	0.40000E-01	1260.	15830.27	4522.93	0.31746E-04
0.13481E 01	74160.	0.40000E-01	900.	16670.94	4763.13	0.44444E-04
0.13881E 01	74940.	0.40000E-01	780.	17599.15	5028.33	0.51282E-04
0.14281E 01	75300.	0.40000E-01	360.	18628.72	5322.49	0.11111E-03
0.14681E 01	75540.	0.40000E-01	240.	19775.09	5650.03	0.16667E-03

TABLE VII - Continued

C-10:ZE41A:WELDED:THIN SECTION OF CASTING:R=0.714:10CPS

PMAX	PMIN	AO	VO	B	W
315.	225.	0.68480	0.	0.20120	2.20000

A	N	DELA	DELN	KMAX	DELK	DADN
0.72480E 00	158280.	0.40000E-01	158280.	5552.88	1872.25	0.25272E-06
0.76480E 00	238080.	0.40000E-01	79800.	5821.01	1948.86	0.50125E-06
0.80480E 00	313320.	0.40000E-01	75240.	7113.93	2032.55	0.53163E-06
0.84480E 00	375960.	0.40000E-01	62640.	7431.07	2123.16	0.63857E-06
0.88480E 00	433200.	0.40000E-01	57240.	7772.74	2220.78	0.69881E-06
0.92480E 00	470100.	0.40000E-01	36900.	8140.12	2325.75	0.10840E-05
0.96480E 00	489120.	0.40000E-01	19020.	8535.57	2438.74	0.21031E-05
0.10048E 01	504780.	0.40000E-01	15660.	8962.53	2560.74	0.25543E-05
0.10448E 01	515820.	0.40000E-01	11040.	9425.88	2690.11	0.36232E-05
0.10848E 01	527160.	0.40000E-01	11340.	9931.75	2837.64	0.35273E-05
0.11248E 01	535920.	0.40000E-01	8760.	10487.93	2996.55	0.45662E-05
0.11648E 01	541320.	0.40000E-01	5400.	11104.00	3172.57	0.74074E-05
0.12048E 01	546060.	0.40000E-01	4740.	11791.05	3368.87	0.84368E-05
0.12448E 01	549900.	0.40000E-01	3840.	12562.06	3589.16	0.10417E-04
0.12848E 01	552720.	0.40000E-01	2820.	13432.10	3837.74	0.14184E-04
0.13248E 01	554820.	0.40000E-01	2100.	14417.91	4119.40	0.19048E-04
0.13648E 01	555780.	0.40000E-01	960.	15539.71	4439.63	0.41668E-04
0.14048E 01	556380.	0.40000E-01	600.	15915.73	4804.50	0.65657E-04

TABLE VII - Continued

C-11:ZE41A:WELDED:THIN SECTION OF CASTING:R=0.714:10CPS

PMAX	PMIN	AO	NO	B	W
420.	300.	0.74420	0.	0.20220	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.78420E 00	34800.	0.40000E-01	34800.	7892.11	2254.89	0.11494E-05
0.82420E 00	321300.	0.40000E-01	286500.	8159.62	2331.32	0.13962E-06
0.86420E 00	363660.	0.40000E-01	42360.	8452.01	2414.86	0.94429E-06
0.90420E 00	384000.	0.40000E-01	20340.	8768.30	2505.23	0.19666E-05
0.94420E 00	398100.	0.40000E-01	14100.	9108.04	2602.30	0.28369E-05
0.98420E 00	410880.	0.40000E-01	12780.	9471.16	2706.05	0.31299E-05
0.10242E 01	419760.	0.40000E-01	8880.	9858.40	2816.69	0.45046E-05
0.10642E 01	426720.	0.40000E-01	6960.	10271.26	2934.65	0.57471E-05
0.11042E 01	433440.	0.40000E-01	6720.	10711.96	3060.56	0.59524E-05
0.11442E 01	441300.	0.40000E-01	7860.	11183.78	3195.36	0.50891E-05
0.11842E 01	446940.	0.40000E-01	5640.	11690.79	3340.23	0.70922E-05
0.12242E 01	451620.	0.40000E-01	4680.	12239.41	3496.69	0.85470E-05
0.12642E 01	455460.	0.40000E-01	3840.	12832.96	3666.56	0.10417E-04
0.13042E 01	457800.	0.40000E-01	2340.	13482.20	3852.06	0.17094E-04
0.13442E 01	459600.	0.40000E-01	1800.	14194.94	4055.70	0.22222E-04
0.13842E 01	461400.	0.40000E-01	1800.	14981.63	4280.46	0.22222E-04
0.14242E 01	462360.	0.40000E-01	960.	15853.70	4529.63	0.41667E-04
0.14642E 01	463020.	0.40000E-01	660.	16824.51	4807.00	0.60606E-04
0.15042E 01	463380.	0.40000E-01	360.	17909.27	5116.65	0.11111E-03

TABLE VII - Continued

C-12:ZE41A:WELDED:THIN SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	AO	NO	B	W
420.	300.	0.58660	0.	0.20100	2.20000

A	N	DELA	DELN	KMAX	DELK	DADN
0.72560E 00	40560.	0.40000E-01	40560.	8761.23	2503.21	0.98519E-06
0.76660E 00	65580.	0.40000E-01	25020.	9120.65	2605.90	0.15987E-05
0.80660E 00	87000.	0.40000E-01	21420.	9513.04	2718.01	0.18674E-05
0.84660E 00	101400.	0.40000E-01	14400.	9937.75	2839.36	0.27778E-05
0.88660E 00	112560.	0.40000E-01	11160.	10395.25	2970.07	0.35842E-05
0.92560E 00	122880.	0.40000E-01	10320.	10887.25	3110.64	0.38760E-05
0.96660E 00	130800.	0.40000E-01	7920.	11416.75	3261.93	0.50505E-05
0.10066E 01	138720.	0.40000E-01	7920.	11988.68	3425.34	0.50506E-05
0.10466E 01	143580.	0.40000E-01	4860.	12609.38	3602.68	0.82304E-05
0.10866E 01	147960.	0.40000E-01	4380.	13287.39	3796.40	0.91324E-05
0.11266E 01	152460.	0.40000E-01	4500.	14033.10	4009.46	0.88889E-05
0.11666E 01	155040.	0.40000E-01	2580.	14859.26	4245.50	0.15504E-04
0.12066E 01	157860.	0.40000E-01	2820.	15780.80	4508.80	0.14184E-04
0.12466E 01	159600.	0.40000E-01	1740.	16815.37	4804.39	0.22988E-04
0.12866E 01	160920.	0.40000E-01	1320.	17983.03	5138.01	0.30303E-04
0.13266E 01	161760.	0.40000E-01	840.	19306.37	5516.11	0.47619E-04

TABLE VII - Continued

C-14:ZE41A:WELDED:THICK SECTION OF CASTING:R=0.714:10CPS

PMAX	PMIN	A0	N0	B	W
420.	300.	0.68510	0.	0.20033	2.20000

A	N	DELA	DELN	KMAX	DELK	DADN
0.72510E 00	26700.	0.40000E-01	26700.	8777.72	2507.92	0.14981E-05
0.76510E 00	55020.	0.40000E-01	28320.	9137.00	2610.57	0.14124E-05
0.80510E 00	72960.	0.40000E-01	17940.	9529.50	2722.71	0.22297E-05
0.84510E 00	87300.	0.40000E-01	14340.	9954.39	2844.11	0.27894E-05
0.88510E 00	99240.	0.40000E-01	11940.	10412.20	2974.91	0.33501E-05
0.92510E 00	108720.	0.40000E-01	9480.	10904.46	3115.56	0.42194E-05
0.96510E 00	116880.	0.40000E-01	8160.	11434.33	3266.95	0.49020E-05
0.10051E 01	120660.	0.40000E-01	3780.	12006.45	3430.41	0.10582E-04
0.10451E 01	124860.	0.40000E-01	4200.	12627.26	3607.79	0.95238E-05
0.10851E 01	128400.	0.40000E-01	3540.	13305.08	3801.45	0.11299E-04
0.11251E 01	132780.	0.40000E-01	4380.	14050.52	4014.43	0.91324E-05
0.11651E 01	135180.	0.40000E-01	2400.	14876.16	4250.33	0.16667E-04
0.12051E 01	137520.	0.40000E-01	2340.	15796.95	4513.41	0.17094E-04
0.12451E 01	138960.	0.40000E-01	1440.	16830.47	4808.71	0.27778E-04

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C-15:ZE41A:WELDED:THICK SECTION OF CASTING:R=0.714:10CPS

PMAX	PMIN	AO	NO	B	N
350.	200.	0.75040	1.	0.20260	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.79040E 00	45120.	0.40000E-01	45120.	5596.85	1884.82	0.84653E-06
0.83040E 00	89160.	0.40000E-01	44040.	6827.50	1949.31	0.90825E-06
0.87040E 00	131820.	0.40000E-01	42660.	7068.91	2019.69	0.93755E-06
0.91040E 00	171000.	0.40000E-01	39180.	7335.02	2095.72	0.10209E-05
0.95040E 00	213060.	0.40000E-01	42060.	7520.56	2177.30	0.95102E-06
0.99040E 00	263980.	0.40000E-01	50920.	7925.66	2264.48	0.78709E-06
0.10304E 01	300660.	0.40000E-01	36780.	8250.91	2357.40	0.10876E-05
0.10704E 01	320580.	0.40000E-01	19920.	8597.75	2456.50	0.20080E-05
0.11104E 01	343380.	0.40000E-01	22800.	8968.06	2562.30	0.17544E-05
0.11504E 01	358620.	0.40000E-01	15240.	9364.76	2675.65	0.25247E-05
0.11904E 01	372720.	0.40000E-01	14100.	9791.30	2797.52	0.28369E-05
0.12304E 01	379860.	0.40000E-01	7140.	10252.41	2929.26	0.56022E-05
0.12704E 01	387240.	0.40000E-01	7380.	10753.55	3072.45	0.54200E-05
0.13104E 01	393840.	0.40000E-01	6600.	11301.21	3228.92	0.60605E-05
0.13504E 01	398700.	0.40000E-01	4860.	11902.87	3400.82	0.82304E-05
0.13904E 01	404100.	0.40000E-01	5400.	12567.47	3590.71	0.74074E-05
0.14304E 01	407940.	0.40000E-01	3840.	13304.80	3801.37	0.10417E-04
0.14704E 01	410400.	0.40000E-01	2460.	14125.92	4035.98	0.16260E 04
0.15104E 01	412260.	0.40000E-01	1860.	15043.15	4299.64	0.21505E-04
0.15504E 01	413460.	0.40000E-01	1200.	16013.62	4591.58	0.33333E 04
0.15904E 01	414000.	0.40000E-01	540.	17222.73	4923.73	[illegible]

TABLE VIII. FATIGUE CRACK PROPAGATION DATA FOR ZE41A and AZ91C MAGNESIUM TESTED IN AIR

C-17: AZ91C: NON-WELDED: THIN SECTION OF CASTING: R=0.714: 10 CPS

PMAX	PMIN	AO	NO	B	[illegible]
490.	350.	0.70800	0.	0.20130	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.74800E 00	28020.	0.40000E-01	28020.	8991.29	2568.94	0.14276E-05
0.78800E 00	62100.	0.40000E-01	34080.	9277.10	2650.60	0.11737E-05
0.82800E 00	90120.	0.40000E-01	28020.	9593.41	2740.97	0.14276E-05
0.86800E 00	114600.	0.40000E-01	24480.	9938.73	2839.64	0.16340E-05
0.90800E 00	138060.	0.40000E-01	23460.	10312.07	2946.31	0.17050E-05
0.94800E 00	162720.	0.40000E-01	24660.	10712.73	3060.78	0.16221E-05
0.98800E 00	193500.	0.40000E-01	30780.	11140.95	3183.13	0.12995E-05
0.10280E 01	205020.	0.40000E-01	11520.	11597.55	3313.59	0.34722E-05
0.10680E 01	216840.	0.40000E-01	11820.	12084.33	3452.67	0.33841E-05
0.11080E 01	229380.	0.40000E-01	12540.	12604.00	3601.14	0.31898E-05
0.11480E 01	243360.	0.40000E-01	13980.	13150.69	3760.20	0.28612E-05
0.11880E 01	256860.	0.40000E-01	13500.	13759.03	3931.15	0.29630E-05
0.12280E 01	267240.	0.40000E-01	10380.	14405.62	4115.89	0.38536E-05
0.12680E 01	277080.	0.40000E-01	9840.	15108.00	4316.57	0.40650E-05
0.13080E 01	286380.	0.40000E-01	9300.	15875.46	4535.85	0.43011E-05
0.13480E 01	292560.	0.40000E-01	6180.	16718.42	4776.69	0.64725E-05
0.13880E 01	300120.	0.40000E-01	7560.	17649.13	5042.61	0.52910E-05
0.14280E 01	307440.	0.40001E-01	7320.	18681.55	5337.59	0.54646E-05
0.14680E 01	312720.	0.40000E-01	5280.	19831.05	5666.02	0.75757E-05
0.15080E 01	318480.	0.40000E-01	5760.	21114.84	6032.81	0.69444E-05
0.15480E 01	322320.	0.40000E-01	3840.	22552.33	6443.52	0.10417E-04
0.15880E 01	323880.	0.40000E-01	1560.	24164.82	6904.23	0.25641E-04
0.16280E 01	324120.	0.40000E-01	240.	25975.02	7421.43	0.16667E-03

C-2B:470 [illegible] THIN SECTION OF CASTING [illegible]

RMAX	RMIN	A0	N0	B	W
400.	200.	0.71[illegible]	0.	0.20143	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.75400E 00	39540.	0.40000E-01	39540.	9163.11	2582.99	0.10116E-05
0.79600E 00	73020.	0.40000E-01	33480.	9331.95	2666.27	0.11947E-05
0.83600E 00	106200.	0.40000E-01	33180.	9652.94	2758.27	0.12055E-05
0.87600E 00	133980.	0.40000E-01	27780.	10034.71	2858.49	0.14399E-05
0.91600E 00	153360.	0.40000E-01	19380.	10383.29	2966.65	0.20640E-05
0.95600E 00	169800.	0.40000E-01	16440.	10799.76	3082.65	0.24331E-05
0.99600E 00	187980.	0.40000E-01	18180.	[illegible].71	3206.49	0.22002E-05
0.10360E 01	202140.	0.40000E-01	14160.	[illegible]	3334.54	0.28249E-05
0.10760E 01	216180.	0.40000E-01	14040.	12177.62	3479.34	0.28490E-05
0.11160E 01	228840.	0.40000E-01	12660.	12704.02	3629.72	0.31596E-05
0.11560E 01	241440.	0.40000E-01	12600.	13269.24	3790.93	0.31746E-05
0.11960E 01	252360.	0.40000E-01	10920.	13875.30	3964.37	0.36630E-05
0.12360E 01	262860.	0.40000E-01	10500.	14532.01	4152.00	0.38095E-05
0.12760E 01	271620.	0.40000E-01	8760.	15246.18	4356.05	0.45662E-05
0.13160E 01	275700.	0.40000E-01	4080.	16027.30	4579.23	0.98039E-05
0.13560E 01	285960.	0.40000E-01	10260.	16886.24	4824.64	0.38986E-05
0.13960E 01	293220.	0.40000E-01	7260.	17935.56	5095.88	0.55096E-05
0.14360E 01	298020.	0.40000E-01	4800.	[illegible].25	5396.93	0.83333E-05
0.14760E 01	301380.	0.40000E-01	3360.	20053.24	5732.36	0.11905E-04
0.15160E 01	306360.	0.40000E-01	4980.	21376.51	6107.29	0.80321E-05
0.15560E 01	309240.	0.40000E-01	2880.	[illegible]	6527.34	0.13889E-04
0.15960E 01	312180.	0.40000E-01	2940.	[illegible]	6928.45	0.13605E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE VIII - Continued

C-19: AZ91C:NON-WELDED:THIN SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	AO	NO	B	W
525.	375.	0.70980	0.	0.20160	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.74980E 00	18600.	0.40000E-01	18600.	9532.21	2752.06	0.21505E-05
0.78980E 00	41520.	0.40000E-01	22920.	9939.51	2839.86	0.17452E-05
0.82980E 00	62760.	0.40000E-01	21240.	10279.32	2936.95	0.18832E-05
0.86980E 00	79440.	0.40000E-01	16680.	10650.16	3042.90	0.23981E-05
0.90980E 00	94860.	0.40000E-01	15420.	11050.83	3157.38	0.25940E-05
0.94980E 00	111900.	0.40000E-01	17040.	11430.86	3280.24	0.23474E-05
0.98980E 00	128820.	0.40000E-01	16920.	11940.33	3411.52	0.23641E-05
0.10298E 01	142260.	0.40000E-01	13440.	12430.22	3551.49	0.29762E-05
0.10698E 01	155760.	0.40000E-01	13500.	12952.46	3700.70	0.29630E-05
0.11098E 01	164700.	0.40000E-01	8940.	13510.18	3860.05	0.44743E-05
0.11498E 01	175980.	0.40000E-01	11280.	14107.47	4030.71	0.35461E-05
0.11898E 01	186720.	0.40000E-01	10740.	14749.80	4214.23	0.37244E-05
0.12298E 01	195300.	0.40000E-01	8580.	15444.04	4412.58	0.45620E-05
0.12698E 01	201840.	0.40000E-01	6540.	16198.56	4628.16	0.61162E-05
0.13098E 01	208200.	0.40000E-01	6360.	17022.78	4863.65	0.62893E-05
0.13498E 01	213060.	0.40000E-01	4860.	17928.59	5122.45	0.82304E-05
0.13898E 01	218400.	0.40000E-01	5340.	18929.96	5408.27	0.74906E-05
0.14298E 01	221760.	0.40000E-01	3360.	20038.61	5725.32	0.11905E-04
0.14698E 01	224040.	0.40000E-01	2280.	21274.45	6078.41	0.17544E-04
0.15098E 01	226200.	0.40000E-01	2160.	22654.75	6472.79	0.18518E-04
0.15498E 01	227580.	0.40000E-01	1380.	24200.86	6914.53	0.28985E-04

TABLE VIII - Continued

C-30:AZ91C:NON-WELDED:THIN SECTION OF CASTING:R=0.71:15 CPS

PMAX	PMIN	AP	NO	B	W
525.	375.	0.71590	0.	0.20180	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.75590E 00	20040.	0.40000E-01	20040.	9657.33	2762.09	0.19960E-05
0.79590E 00	36360.	0.40000E-01	16320.	9479.40	2851.26	0.24510E-05
0.83590E 00	53220.	0.40000E-01	16860.	10323.64	2949.61	0.23725E-05
0.87590E 00	66120.	0.40000E-01	12900.	10698.75	3056.79	0.31008E-05
0.91590E 00	78540.	0.40000E-01	12420.	11103.55	3172.44	0.32206E-05
0.95590E 00	94020.	0.40000E-01	15480.	11577.59	3296.46	0.25840E-05
0.99590E 00	103200.	0.40000E-01	9180.	12031.14	3428.90	0.43573E-05
0.10359E 01	112080.	0.40000E-01	8880.	12495.33	3570.10	0.45045E-05
0.10759E 01	120480.	0.40000E-01	8400.	13022.25	3720.64	0.47619E-05
0.11159E 01	127200.	0.40000E-01	6720.	13595.06	3881.45	0.59524E-05
0.11559E 01	134760.	0.40000E-01	7560.	14188.32	4053.81	0.52910E-05
0.11959E 01	140400.	0.40000E-01	5640.	14637.50	4239.29	0.70922E-05
0.12359E 01	145620.	0.40000E-01	5220.	15539.63	4439.89	0.76628E-05
0.12759E 01	150660.	0.40000E-01	5040.	16303.27	4658.08	0.79365E-05
0.13159E 01	155700.	0.40000E-01	5040.	17139.42	4896.69	0.79365E-05
0.13559E 01	160020.	0.40000E-01	4320.	18055.77	5159.08	0.92592E-05
0.13959E 01	164040.	0.40000E-01	4020.	19071.83	5449.09	0.99502E-05
0.14359E 01	167760.	0.40000E-01	3720.	20198.46	5770.99	0.10753E-04
0.14759E 01	171960.	0.40000E-01	4200.	21453.50	6129.57	0.95238E-05
0.15159E 01	174600.	0.40000E-01	2640.	22855.60	6530.46	0.15152E-04
0.15559E 01	176280.	0.40000E-01	1680.	24428.30	6979.52	0.23809E-04
0.15959E 01	177120.	0.40000E-01	840.	26191.09	7483.17	0.47619E-04

TABLE VIII - Continued

C-21:AZ91C:WELDED:THIN SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	AO	NO	B	W
455.	325.	0.74770	0.	0.20147	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.78770E 00	54120.	0.40000E-01	54120.	8605.11	2458.60	0.73910E-06
0.82770E 00	84360.	0.40000E-01	30240.	8898.32	2542.38	0.13228E-05
0.85770E 00	112620.	0.40000E-01	28260.	9218.55	2633.87	0.14154E-05
0.90770E 00	133920.	0.40000E-01	21300.	9554.71	2732.78	0.18779E-05
0.94770E 00	161880.	0.40000E-01	27960.	9936.29	2838.94	0.14306E-05
0.98770E 00	180360.	0.40000E-01	18480.	10333.34	2952.38	0.21645E-05
0.10277E 01	198060.	0.40000E-01	17700.	10756.82	3073.38	0.22599E-05
0.10677E 01	219120.	0.40000E-01	21060.	11208.21	3202.35	0.18993E-05
0.11077E 01	237240.	0.40000E-01	18120.	11690.18	3340.05	0.22075E-05
0.11477E 01	247260.	0.40000E-01	10020.	12206.19	3487.48	0.39920E-05
0.11877E 01	258360.	0.40000E-01	11100.	12761.14	3646.04	0.36036E-05
0.12277E 01	268440.	0.40000E-01	10080.	13360.67	3817.34	0.39682E-05
0.12677E 01	276360.	0.40000E-01	7920.	14011.94	4003.41	0.50505E-05
0.13077E 01	283920.	0.40000E-01	7560.	14723.45	4206.70	0.52910E-05
0.13477E 01	291300.	0.40000E-01	7380.	15504.98	4430.00	0.54200E-05
0.13877E 01	297720.	0.40000E-01	6420.	16367.93	4676.55	0.62305E-05
0.14277E 01	302880.	0.40000E-01	5160.	17324.86	4949.96	0.77519E-05
0.14677E 01	307200.	0.40000E-01	4320.	18390.49	5254.43	0.92593E-05
0.15077E 01	311760.	0.40000E-01	4560.	19580.48	5594.42	0.87719E-05
0.15477E 01	312720.	0.40000E-01	960.	20913.33	5975.24	0.41667E-04

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TABLE VIII Continued

C-[illegible]:AZ91C:[illegible]

PMAX	PMIN	AO	NO	B	W
490.	350.	0.75200	0.	0.20140	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.[illegible]200E 00	2142[illegible].	0.400000E-01	2142[illegible].	[illegible]	2657.94	0.1[illegible]674E-05
0.932000E 00	47160.	0.400000E-01	25740.	[illegible].82	2749.09	0.15540E-05
0.972000E 00	85320.	0.400000E-01	38160.	[illegible].91	2848.55	0.11048[illegible]E-05

C-22:AZ91C:[illegible]:THIN SECTION OF CASTING:[illegible] CPS

PMAX	PMIN	AO	NO	B	W
490.	350.	0.91200	0.	0.20140	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.95200E 00	10680.	0.40000E-01	10680.	10748.95	3071.13	0.37453E-05
0.99200E 00	21120.	0.40000F-01	10440.	11179.80	3194.2[illegible]	0.38314E-05
0.10320E 01	36420.	0.40000E-01	15300.	[illegible]	3325.44	0.26144E-05
0.[illegible]20E 01	49320.	0.40000F-01	12900.	12129.77	3465.36	0.31008E-05
0.11020F 01	56760.	0.30001E-01	7440.	12517.61	3576.46	0.40324E-05
0.11420F 01	64920.	0.40000E-01	8160.	130[illegible].18	3733.75	0.49020E-05
0.[illegible]20E 01	70980.	0.40000F-01	[illegible]060.	13[illegible]	3902.72	0.65007E-05
0.[illegible]	734[illegible].	0.400000E-01	[illegible]	[illegible]	[illegible]	0.15[illegible]E-04
0.12620E 01	814[illegible].	0.40000E-01	[illegible]	[illegible]	4283.2[illegible]	0.40751E-05
0.[illegible]020F 01	841[illegible].	0.400000E-01	[illegible]	[illegible]	[illegible]	0.15[illegible]E-04
0.[illegible]	860[illegible].	[illegible]	[illegible]	[illegible]	[illegible]	0.23[illegible]E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.31[illegible]E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.[illegible]E-04

TABLE VIII - Continued

C-23:AZ91C:WELDED:THIN SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	A0	N0	B	W
490.	350.	0.70680	0.	0.19980	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.74680E 00	18120.	0.40000E-01	18120.	9050.68	2585.91	0.22075E-05
0.78680E 00	40020.	0.40000E-01	21900.	9337.64	2667.90	0.18265E-05
0.82680E 00	69240.	0.40000E-01	29220.	9655.45	2758.70	0.13689E-05
0.86680E 00	91560.	0.40000E-01	22320.	10002.53	2857.87	0.17921E-05
0.90680E 00	111900.	0.40000E-01	20340.	10377.82	2565.09	0.19656E-05
0.94680E 00	132480.	0.40000E-01	20580.	10780.64	3080.18	0.19436E-05
0.98680E 00	150720.	0.40000E-01	18240.	11211.25	3203.21	0.21930E-05
0.10268E 01	166680.	0.40000E-01	15960.	11670.42	3334.41	0.25063E-05
0.10668E 01	175920.	0.40000E-01	9240.	12159.93	3474.27	0.43290E-05
0.11068E 01	185160.	0.40000E-01	9240.	12682.46	3623.56	0.43290E-05
0.11468E 01	193440.	0.40000E-01	8280.	13241.98	3783.42	0.48309E-05
0.11868E 01	201840.	0.40000E-01	8400.	13843.56	3955.30	0.47619E-05
0.12268E 01	206280.	0.40000E-01	4440.	14493.42	4140.98	0.90090E-05
0.12668E 01	215820.	0.40000E-01	9540.	15199.36	4342.68	0.41929E-05
0.13068E 01	220920.	0.40000E-01	5100.	15970.38	4562.96	0.78431E-05
0.13468E 01	224640.	0.40000E-01	3720.	16817.23	4804.92	0.10753E-04
0.13868E 01	234360.	0.40000E-01	9720.	17752.09	5072.03	0.41152E-05
0.14268E 01	242400.	0.40000E-01	8040.	18788.91	5368.26	0.49751E-05
0.14668E 01	252060.	0.40000E-01	9660.	19943.26	5698.07	0.41408E-05
0.15068E 01	258480.	0.40000E-01	6420.	21232.45	6066.41	0.62305E-05
0.15468E 01	260520.	0.40000E-01	2040.	22675.86	6478.82	0.19608E-04
0.15868E 01	261900.	0.40000E-01	1380.	24294.61	6541.32	0.28985E-04

C-26:47215: [illegible]

PMAX	PMIN	A0	N0	B	W
420.	200.	0.71160	0.	0.20100	2.50000

A	N	DELA	DSIN	KMAX	DELK	DADN
0.75160E 00	59820.	0.40000E-01	59820.	[illegible]	2211.23	0.55357E-06
0.79160E 00	122570.	0.40000E-01	62700.	[illegible]	2282.01	0.63796E-06
0.83160E 00	183360.	0.40000E-01	67840.	[illegible]	2360.25	0.45527E-06
0.87160E 00	257220.	0.40000E-01	46860.	8559.59	2445.57	0.85351E-06
0.91160E 00	336120.	0.40000E-01	78900.	8842.12	2537.75	0.50697E-06
0.95160E 00	385020.	0.40000E-01	48900.	9228.71	2636.63	0.81800E-06
0.99160E 00	424500.	0.40000E-01	39480.	9597.93	2742.26	0.10132E-05
0.10316E 01	456360.	0.40000E-01	31860.	9992.16	2854.90	0.12555E-05
0.10716E 01	485280.	0.40000E-01	28920.	10412.44	2974.08	0.13921E-05
0.11116E 01	510120.	0.40000E-01	24940.	10861.28	3103.22	0.16103E-05
0.11516E 01	524040.	0.40000E-01	13920.	11342.04	3241.58	0.28736E-05
0.11916E 01	544020.	0.40000E-01	19980.	11859.21	3388.35	0.20020E-05
0.12316E 01	556920.	0.40000E-01	12900.	12418.32	3546.09	0.31008E-05
0.12716E 01	567660.	0.40000E-01	10740.	13025.96	3721.70	0.37244E-05
0.13116E 01	578460.	0.40000E-01	10800.	13690.18	3911.48	0.37037E-05
0.13516E 01	587520.	0.40000E-01	9060.	14420.14	4120.04	0.44150E-05
0.13916E 01	594780.	0.40000E-01	7260.	15226.42	4350.41	0.55096E-05
0.14316E 01	604560.	0.40000E-01	9780.	16121.15	4606.04	0.40900E-05
0.14716E 01	611340.	0.40000E-01	6780.	17117.60	4890.74	0.58997E-05
0.15116E 01	617040.	0.40000E-01	5700.	18235.93	5208.84	0.70175E-05
0.15516E 01	622200.	0.40001E-01	5160.	19477.81	5565.09	0.77521E-05
0.15916E 01	627000.	0.40000E-01	4800.	20876.09	5964.60	0.83333E-05
0.16316E 01	629640.	0.40000E-01	2640.	22544.35	6413.24	0.15152E-04

TABLE VIII - Continued

C-25:A201C:NON-WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	A0	N0	B	M
490.	350.	0.71440	0.	0.20223	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.75440E 00	33540.	0.40000E-01	33540.	8993.39	2569.54	0.11926E-05
0.79440E 00	63480.	0.40000E-01	29940.	9282.84	2652.24	0.13360E-05
0.83440E 00	97140.	0.40000E-01	33660.	9602.35	2743.53	0.11884E-05
0.87440E 00	123600.	0.40000E-01	26460.	9950.64	2843.04	0.15117E-05
0.91440E 00	153600.	0.40000E-01	30000.	10326.61	2950.46	0.13333E-05
0.95440E 00	174000.	0.40000E-01	20400.	10729.86	3065.67	0.19608E-05
0.99440E 00	195660.	0.40000E-01	21660.	11160.55	3188.73	0.18467E-05
0.10344E 01	216060.	0.40000E-01	20400.	11613.67	3319.91	0.19608E-05
0.10744E 01	233160.	0.40000E-01	17100.	12109.29	3459.80	0.23392E-05
0.11144E 01	249420.	0.40000E-01	16260.	12632.18	3609.19	0.24600E-05
0.11544E 01	264240.	0.40000E-01	14820.	13192.46	3769.27	0.26991E-05
0.11944E 01	277680.	0.40000E-01	13440.	13795.37	3941.53	0.29762E-05
0.12344E 01	288360.	0.40000E-01	10680.	14447.27	4127.79	0.37453E-05
0.12744E 01	296880.	0.40000E-01	8520.	15156.27	4330.36	0.46948E-05
0.13144E 01	306360.	0.40000E-01	9480.	15931.33	4551.81	0.42194E-05
0.13544E 01	314880.	0.40000E-01	8520.	16783.50	4795.29	0.46948E-05
0.13944E 01	318120.	0.40000E-01	3240.	17725.26	5064.36	0.12346E-04
0.14344E 01	322800.	0.40000E-01	4680.	18770.45	5362.98	0.85470E-05
0.14744E 01	327600.	0.40000E-01	4800.	19934.64	5695.61	0.83333E-05
0.15144E 01	331920.	0.40000E-01	4320.	21235.91	6067.40	0.92592E-05
0.15544E 01	335580.	0.40001E-01	3660.	22693.16	6483.76	0.10929E-04
0.15944E 01	338760.	0.40000E-01	3180.	24323.29	6950.94	0.12579E-04

TABLE VIII - Continued

C-26: AZ[illegible]

PMAX	PMIN	A0	[illegible]	B	[illegible]
490.	350.	0.75930	0.	0.19337	2.50000

A	N	DELA	DELN	[illegible]	DELK	GADN
0.79930E 00	[illegible]	0.40000E-01	35700.	[illegible]	2701.17	0.11204E-05
0.83930E 00	54090.	0.40000E-01	[illegible]	[illegible]	2794.83	[illegible]
0.87930E 00	[illegible]	0.40000E-01	25320.	[illegible]	2396.74	0.15793E-05
0.91930E 00	118080.	0.40000E-01	[illegible]	[illegible]	3006.69	0.13947E-05
0.95930E 00	142260.	0.40000E-01	24190.	[illegible]	3124.52	[illegible]
0.99930E 00	[illegible]	0.40000E-01	[illegible]	[illegible]	[illegible]	[illegible]
0.10393E 01	179520.	0.40000E-01	19440.	[illegible]	3384.42	0.20576E-05
0.10793E 01	201240.	0.40000E-01	21720.	[illegible]	3527.45	0.19416E-05
0.11193E 01	221400.	0.40000E-01	[illegible]	[illegible]	[illegible]	[illegible]
0.11593E 01	234120.	0.40000E-01	12720.	13454.19	3844.05	0.31447E-05
0.11993E 01	241560.	0.40000E-01	7440.	14071.41	4020.40	0.53763E-05
0.12393E 01	248880.	0.40000E-01	7320.	14739.35	4211.24	0.54645E-05
0.12793E 01	258120.	0.40000E-01	9240.	15466.13	4418.89	0.43290E-05
0.13193E 01	271500.	0.40000E-01	13380.	16261.39	4646.11	0.29995E-05
0.14393E 01	294780	0.12000E 00	[illegible]	[illegible]	5479.79	[illegible]
0.14793E 01	302520.	0.40000E-01	7740.	20374.54	5821.30	0.51680E-05
0.15193E 01	309480.	0.40001E-01	6960.	21712.75	6203.64	0.57473E-05
0.15593E 01	316200.	0.40000E-01	6720.	[illegible]	6631.91	0.59524E-05
0.15993E 01	322200.	0.40000E-01	6000.	[illegible]	7112.55	0.65657E-05
0.16393E 01	329460.	0.40000E-01	7260.	[illegible]	7652.10	0.55096E-05
0.16793E 01	333240.	0.40000E-01	3780.	[illegible]	8257.92	0.10592E-04

TABLE VIII - Continued

C-27:AZ91C:NON-WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	FMIN	AO	NO	B	W
490.	350.	0.70930	0.	0.19930	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.74930E 00	21420.	0.40000E-01	21420.	9090.43	2597.27	0.18674E-05
0.78930E 00	58320.	0.40000E-01	36900.	9380.07	2680.02	0.13840E-05
0.82930E 00	92520.	0.40000E-01	34200.	9700.58	2771.59	0.11696E-05
0.86930E 00	115800.	0.40000E-01	23280.	10050.29	2871.51	0.17182E-05
0.90930E 00	138480.	0.40000E-01	22680.	10428.30	2979.51	0.17637E-05
0.94930E 00	159420.	0.40000E-01	20940.	10833.89	3095.40	0.19102E-05
0.98930E 00	175680.	0.40000E-01	16260.	11257.30	3219.23	0.24600E-05
0.10293E 01	189540.	0.40000E-01	13860.	11729.45	3351.27	0.28860E-05
0.10693E 01	201540.	0.40000E-01	12000.	12222.14	3492.04	0.33333E-05
0.11093E 01	212880.	0.40000E-01	11340.	12748.21	3642.35	0.35273E-05
0.11493E 01	222900.	0.40000E-01	10020.	13311.65	3803.33	0.39920E-05
0.11893E 01	234000.	0.40000E-01	11100.	13917.52	3976.43	0.36036E-05
0.12293E 01	242940.	0.40000E-01	8940.	14572.30	4163.52	0.44743E-05
0.12693E 01	253620.	0.40001E-01	10680.	15283.82	4366.80	0.37454E-05
0.13093E 01	261720.	0.40000E-01	8100.	16061.23	4588.92	0.49383E-05
0.13493E 01	272220.	0.40000E-01	10500.	16915.39	4832.97	0.38095E-05
0.13893E 01	282480.	0.40000E-01	10260.	17858.48	5102.42	0.38986E-05
0.14293E 01	288780.	0.40000E-01	6300.	18904.79	5401.37	0.63492E-05
0.14693E 01	292200.	0.40000E-01	3420.	20069.98	5734.28	0.11696E-04
0.15093E 01	296460.	0.40000E-01	4260.	21371.33	6106.09	0.93897E-05
0.15493E 01	300420.	0.40000E-01	3960.	22828.82	6522.52	0.10101E-04

TABLE VIII - Continued

C-2S:AZ[illegible]-WELD[illegible] SECTION OF CAST[illegible]

PMAX	PMIN	AO	NO	B	W
455.	[illegible]	[illegible]	[illegible]	0.23423	[illegible]

A	N	DELA	DELN	KMAX	DELK	DADN
0.88830E 00	27480.	0.40000E-01	27490.	9365.37	2673.82	0.14559E-05
0.92830E 00	53520.	0.40000E-01	26040.	9715.76	2776.06	0.15361E-05
0.96830E 00	95250.	0.40000E-01	41760.	10095.49	2885.57	0.95765E-06
0.10083E 01	115320.	0.40000E-01	20040.	10598.43	3002.41	0.19960E-05
0.10483E 01	143880.	0.40000E-01	28840.	[illegible]	3126.95	[illegible]
0.10883E 01	160500.	0.40000E-01	16620.	11409.39	3259.82	0.24067E-05
0.11283E 01	173700.	0.40000E-01	13200.	[illegible]	3401.56	[illegible]
0.11683E 01	188400.	0.40000E-01	14700.	[illegible]	3554.25	0.27211E-05
0.12083E 01	207000.	0.40000E-01	18600.	13014.76	3718.50	0.21505E-05
0.12483E 01	219600.	0.40000E-01	12600.	13637.70	3896.49	0.31746E-05
0.12883E 01	230400.	0.40000E-01	10800.	14316.27	4090.36	0.37037E-05
0.13283E 01	240420.	0.40000E-01	10020.	15059.73	4302.78	0.39921E-05
0.13683E 01	249120.	0.40000E-01	8700.	15878.53	4536.72	0.45977E-05
0.14083E 01	258180.	0.40000E-01	9060.	16784.64	4795.67	0.44150E-05
0.14483E 01	268140.	0.40000E-01	9960.	17792.07	5083.45	0.40161E-05
0.14883E 01	272640.	0.40000E-01	4500.	18915.48	5404.42	0.88889E-05
0.15283E 01	275520.	0.40000E-01	2880.	20171.77	5763.36	0.13889E-04
0.15683E 01	278040.	0.40000E-01	2520.	21590.29	6165.80	0.15873E-04
0.16083E 01	278880.	0.40000E-01	840.	23160.57	6617.30	0.47619E-04
0.16483E 01	279000.	0.40000E-01	120.	24935.15	7124.33	0.33333E-03

TABLE VIII - Continued

C-29:AZ91C:WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	AO	NO	B	W
490.	350.	0.79430	0.	0.20167	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.83430E 00	14520.	0.40000E-01	14520.	9528.22	2750.92	0.27548E-05
0.87430E 00	25920.	0.40000E-01	11400.	9977.36	2850.67	0.35088E-05
0.91430E 00	35940.	0.40000E-01	10020.	10354.33	2958.38	0.39920E-05
0.95430E 00	47280.	0.40000E-01	11340.	10759.62	3073.89	0.35273E-05
0.99430E 00	60060.	0.40000E-01	12780.	11193.44	3197.27	0.31299E-05
0.10343E 01	64380.	0.40000E-01	4320.	11650.77	3328.79	0.92592E-05
0.10743E 01	69480.	0.40000E-01	5100.	12141.60	3469.03	0.78431E-05
0.11143E 01	73020.	0.40000E-01	3540.	12665.90	3618.83	0.11299E-04
0.11543E 01	76320.	0.40000E-01	3300.	13227.62	3779.32	0.12121E-04
0.11943E 01	79800.	0.40000E-01	3480.	13832.06	3952.02	0.11494E-04
0.12343E 01	81660.	0.40000E-01	1860.	14485.71	4138.77	0.21505E-04
0.12743E 01	82920.	0.40000E-01	1260.	15196.43	4341.84	0.31746E-04
0.13143E 01	84240.	0.40000E-01	1320.	15973.63	4563.89	0.30303E-04
0.13543E 01	84480.	0.40000E-01	240.	16827.88	4807.96	0.16667E-03
0.13943E 01	84540.	0.40001E-01	60.	17771.99	5077.71	0.65658E-03

C-30:AZ91C:WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	A0	N0	B	W
455.	325.	0.71060	0.	0.20153	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.75060E 00	19200.	0.40000E-01	19200.	8355.89	2387.40	0.20833E-05
0.79060E 00	40560.	0.40000E-01	21360.	8622.84	2463.67	0.18727E-05
0.83060E 00	63900.	0.40000E-01	23340.	8918.03	2548.01	0.17139E-05
0.87060E 00	79380.	0.40000E-01	15480.	9239.99	2640.00	0.25940E-05
0.91060E 00	93660.	0.40000E-01	14280.	9587.97	2739.42	0.28011E-05
0.95060E 00	105360.	0.40000E-01	11700.	9951.29	2846.08	0.34183E-05
0.99060E 00	114420.	0.40000E-01	9060.	10350.08	2960.02	0.44150E-05
0.10306E 01	124680.	0.40000E-01	10260.	10785.39	3081.54	0.38986E-05
0.10706E 01	136860.	0.40000E-01	12180.	11233.73	3211.07	0.32841E-05
0.11106E 01	143100.	0.40001E-01	6240.	11722.93	3349.41	0.64104E-05
0.11506E 01	149520.	0.40000E-01	6420.	12241.52	3497.58	0.62305E-05
0.11906E 01	155820.	0.40000E-01	6300.	12799.20	3656.92	0.63492E-05
0.12306E 01	160980.	0.40000E-01	5160.	13402.09	3829.17	0.77519E-05
0.12706E 01	165300.	0.40000E-01	4320.	14057.23	4016.35	0.92592E-05
0.13106E 01	168720.	0.40000E-01	3420.	14773.28	4220.94	0.11696E-04
0.13506E 01	172500.	0.40000E-01	3780.	15550.03	4445.72	0.10582E-04
0.13906E 01	176640.	0.40000E-01	4140.	16429.03	4694.01	0.95618E-05
0.14306E 01	178980.	0.40000E-01	2340.	17393.21	4969.49	0.17094E-04

TABLE VIII - Continued

C-31:AZ91C:WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	AO	NO	B	W
525.	375.	0.75360	0.	0.19917	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.79360E 00	14760.	0.40000E-01	14760.	10032.05	2883.44	0.27100E-05
0.83360E 00	28320.	0.40000E-01	13560.	10439.05	2982.59	0.29498E-05
0.87360E 00	34020.	0.40000E-01	5700.	10817.39	3090.68	0.70175E-05
0.91360E 00	37920.	0.40000E-01	3900.	11225.80	3207.37	0.10256E-04
0.95360E 00	42480.	0.40000E-01	4560.	11663.84	3332.53	0.87719E-05
0.10336E 01	56520.	0.80000E-01	14040.	12630.65	3608.76	0.56980E-05
0.10736E 01	60720.	0.40000E-01	4200.	13162.56	3760.73	0.95238E-05
0.11136E 01	64980.	0.40000E-01	4260.	13730.59	3923.03	0.93897E-05
0.11536E 01	67380.	0.40000E-01	2400.	14339.27	4096.93	0.16667E-04
0.11936E 01	69960.	0.40000E-01	2580.	14994.15	4284.04	0.15504E-04
0.12336E 01	71940.	0.40000E-01	1980.	15702.21	4486.35	0.20202E-04
0.12736E 01	72360.	0.40000E-01	420.	15472.23	4706.35	0.95238E-04
0.13136E 01	72780.	0.40000E-01	420.	17313.98	4946.85	0.95238E-04

TABLE VIII - Continued

C-32:AZ91C:WELDED:THICK SECTION OF CASTING:R=0.714:10 CPS

PMAX	PMIN	A0	N0	B	W
350.	250.	0.71060	0.	0.20120	2.50000

A	N	DELA	DELN	KMAX	DELK	DADN
0.75060E 00	151440.	0.40000E-01	151440.	6438.14	1839.47	0.26413E-06
0.79060E 00	237480.	0.40000E-01	86040.	5543.83	1898.24	0.45490E-06
0.83060E 00	296040.	0.40000E-01	58560.	6871.27	1963.22	0.68305E-06
0.87060E 00	343680.	0.40000E-01	47640.	7119.34	2034.10	0.33963E-06
0.91060E 00	467880.	0.40000E-01	124200.	7387.45	2110.70	0.32206E-06
0.95060E 00	506760.	0.40000E-01	38880.	7675.09	2192.83	0.10284E-05
0.99060E 00	521220.	0.40000E-01	14460.	7942.46	2280.67	0.27662E-05
0.10306E 01	553320.	0.40000E-01	32100.	8210.05	2374.30	0.12451E-05
0.10706E 01	583440.	0.40000E-01	30120.	8659.35	2474.10	0.13280E-05
0.11106E 01	613560.	0.40000E-01	30120.	9037.43	2580.69	0.13291E-05
0.11506E 01	634620.	0.40000E-01	21060.	9431.49	2694.85	0.18993E-05
0.11906E 01	647460.	0.40000E-01	12840.	9851.68	2817.62	0.31153E-05
0.12306E 01	663660.	0.40000E-01	16200.	10326.20	2950.34	0.24691E-05
0.12706E 01	672120.	0.40000E-01	8460.	10830.99	3094.57	0.47281E-05
0.13106E 01	681600.	0.40000E-01	9480.	11382.70	3252.20	0.42194E-05
0.13506E 01	691140.	0.40000E-01	9540.	11998.88	3425.40	0.41929E-05
0.13906E 01	695520.	0.40000E-01	4380.	12658.44	3616.70	0.91324E-05
0.14306E 01	699360.	0.40000E-01	3840.	13401.33	3828.95	0.10417E-04
0.14706E 01	702120.	0.40000E-01	2760.	14228.61	4065.32	0.14493E-04
0.15106E 01	705000.	0.40000E-01	2880.	15152.82	4329.38	0.13889E-04
0.15506E 01	706560.	0.40000E-01	1560.	16187.79	4625.08	0.25641E-04
0.15906E 01	707460.	0.40000E-01	900.	17348.77	4956.79	0.44444E-04
0.16306E 01	708240.	0.40000E-01	780.	18652.10	5329.17	0.51282E-04

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3. TENTATIVE METHOD OF TEST FOR PLANE-STRAIN FRACTURE TOUGHNESS OF METALLIC MATERIALS, E399-70T, American Society for Testing and Materials.

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This report presents engineering material properties for ZE41A and AZ91C magnesium developed from a coupon test program. Static, fatigue bending, and fatigue crack propagation characteristics for welded and non-welded magnesium are presented in this document.

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Fatigue Test						
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Welding						
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BOEING

VERTOL DIVISION

8-5100-16-116
5 January 1973

To: Commanding General
U.S. Army Av[illegible] Systems Command
P. O. B[illegible]
St. Louis, Missouri 66

Attention: AMCPM-HLS Office of the [illegible]oject Manager, Heavy Lift Transport Avi[illegible]ion Systems

[illegible]bjec[illegible]: Contract DAAJ [illegible]-71-C-08[illegible] [illegible]P40); Final Technology De[illegible]lopment [illegible]port; Model 301 HLH/AT[illegible]: Trans[illegible] [illegible]sing Material Evaluation

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1. The reference submitted Boeing Document T301-10147-1, Revision A. The enclosed drawing was inadvertently omitted from these copies and should be inserted in the documents following page 4. Page 4 is blank

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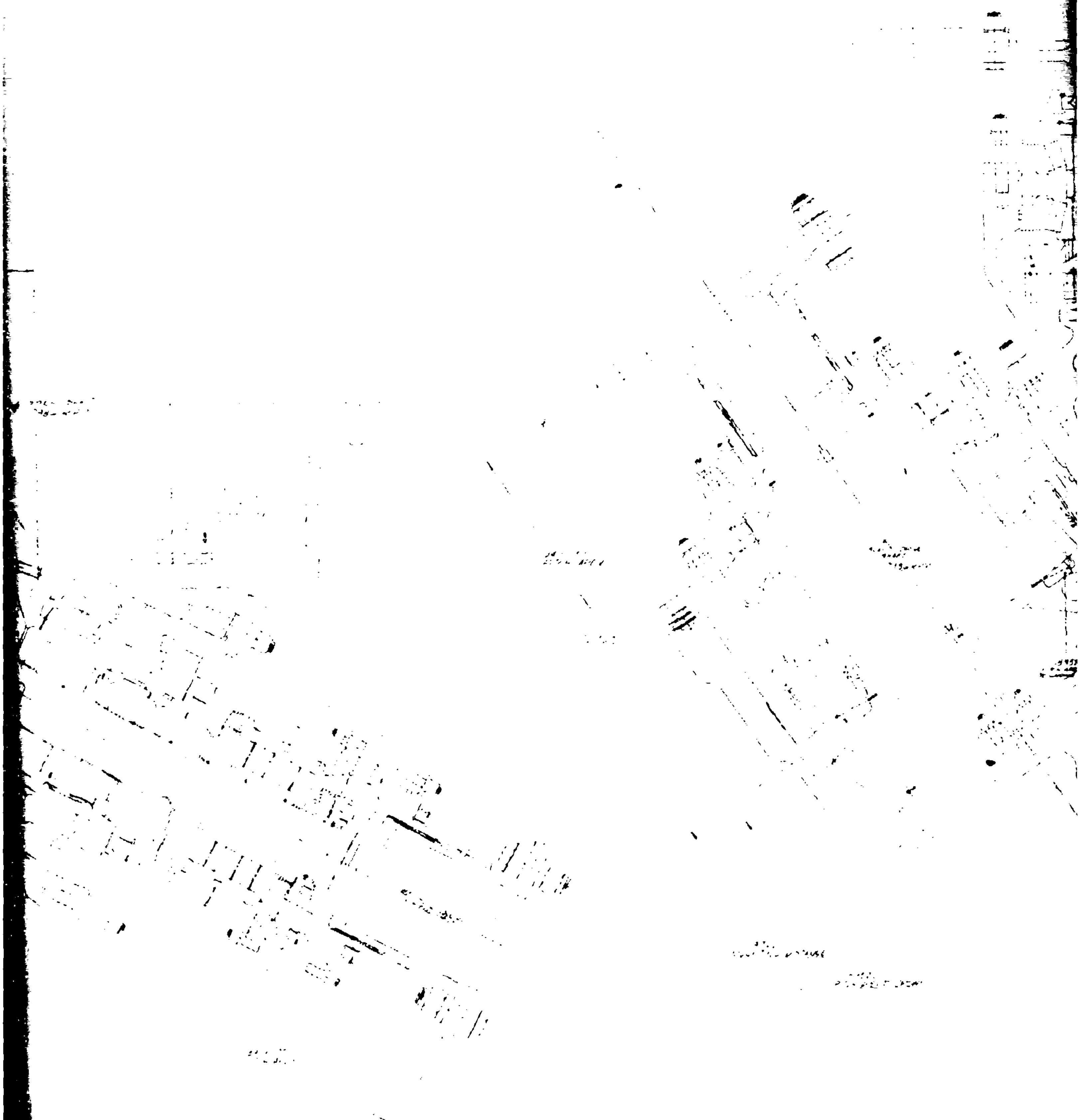

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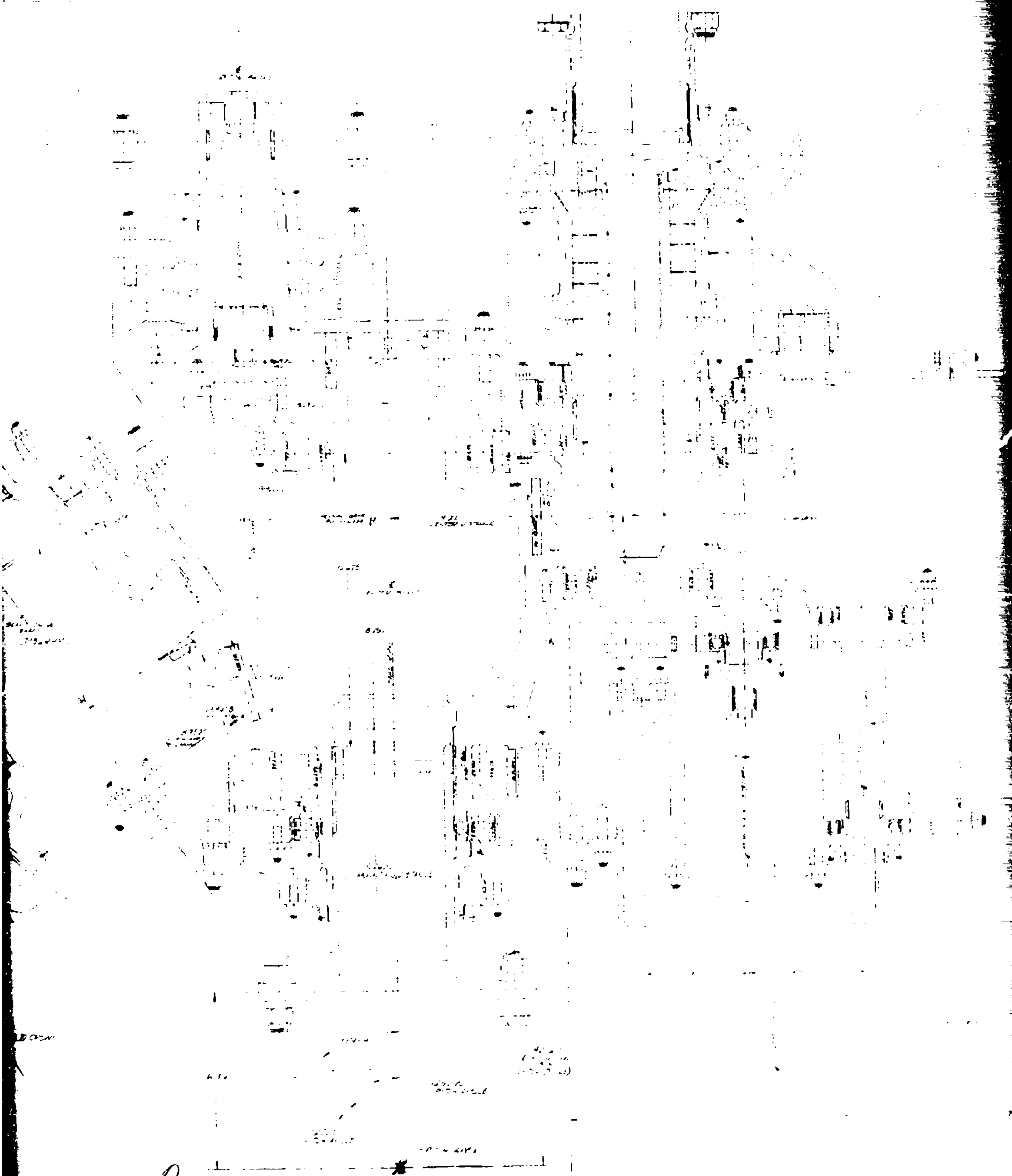

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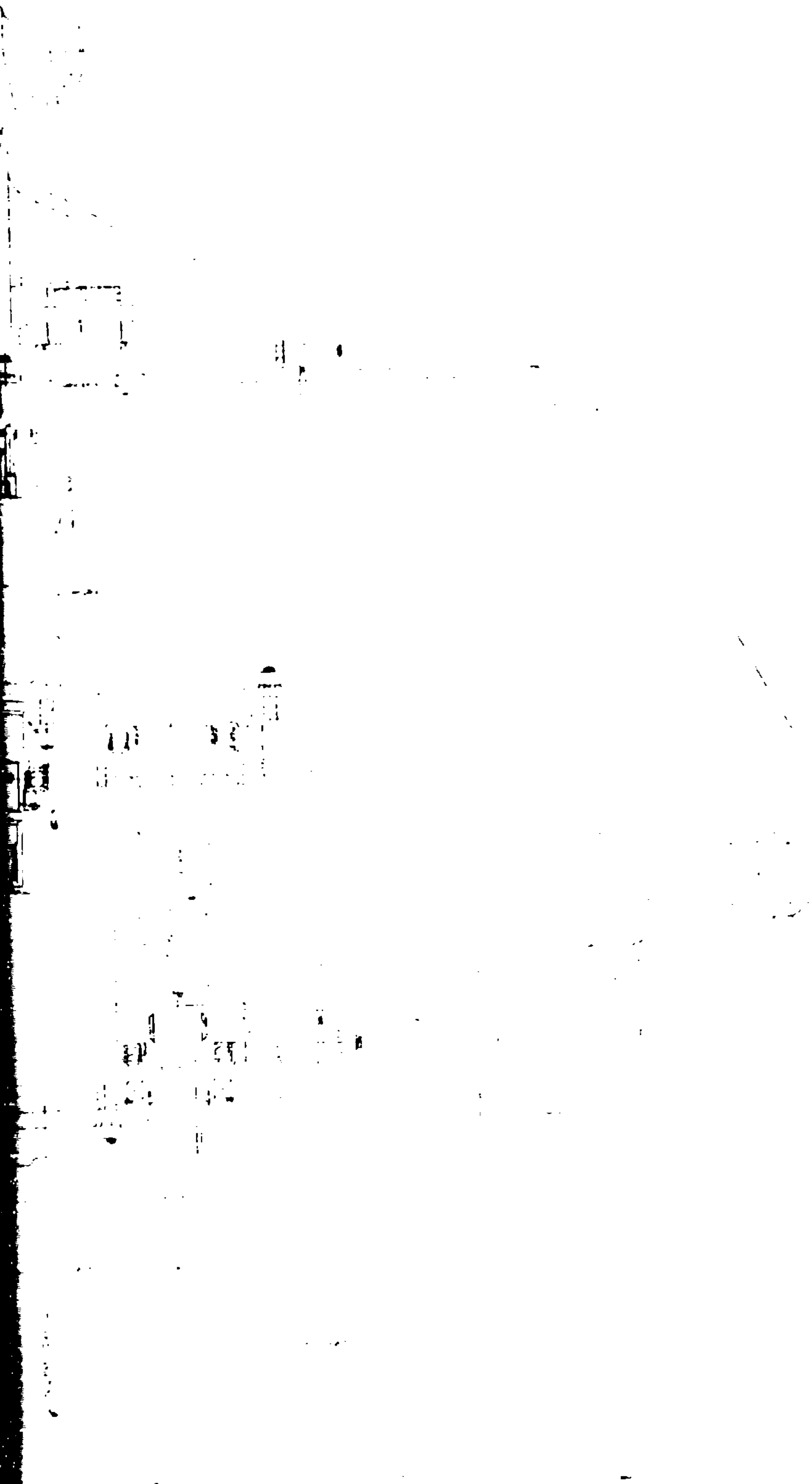

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